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A THEORETICAL EVALUATION OF FEE SYSTEMS FOR PRIVATE GRAZING ON FEDERAL LANDS

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A THEORETICAL EVALUATION OF FEE SYSTEMS FOR PRIVATE GRAZING ON FEDERAL LANDS

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A THEORETICAL EVALUATION OF FEE SYSTEMS FOR PRIVATE GRAZING ON FEDERAL LANDS[1]

By

Ray F. Brokken and Bruce A. McCarl

PART I. INTRODUCTION AND LEGISLATIVE BACKGROUND

The purposes of this paper are (1) to develop a theoretical and technical economic framework within which to review the situation involved with private grazing on federal lands and (2) to evaluate several different fee systems utilizing this theoretical framework and certain administrative criteria. The literature pertaining to this subject is abundant and comprehensive. The theme of economic efficiency and equity, as well as conservation or range enhancement, is basic to the literature of the last 30 to 35 years and is the focus of this paper as well.

The paper is organized in six main parts. Part I consists of the

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1. This paper benefits from comments by Professor Stanley F. Miller, Dr. Robert House, Dr. Henry Gilliam, and several other reviewers in ERS on an earlier draft. Useful discussions were also provided by Professors Darrell Hueth and Stephen Buccola during the course of the paper's development. Responsibility for material herein rests solely with the authors.

introduction containing material on the legislative background to the area of inquiry. Part II presents theoretical and empirical background. Part III presents fee formulas and administrative criteria for their evaluation. Part IV discusses the properties of the formulas and their components. Part V presents the formula evaluation and Part VI is the summary.

The Independent Officer Appropriation Act of 1952 provides statutory direction for Federal fees for private use of publicly-owned resources. This Act requires that fees shall be:

- Self sustaining to the fullest extent possible.
- Uniform among all agencies.
- Subject to Federal Executive policy.
- Fair and equitable to the public and user

unless otherwise directed by specific acts of Congress.

This last phrase allows Congress complete latitude in setting fees. However, recent hearings regarding grazing fees on federal lands clearly demonstrate a strong commitment to these principles on the part of both Congress and the Federal Executive branch.

Federal Executive policy is stated in the 1959 Bureau of the Budget, Circular A-25. The circular states that "A reasonable charge...should be made to each identifiable recipient for a measurable unit or amount of Government service or property from which he derives a special benefit...Where federally-owned resources or property are leased or sold, a fair market value should be obtained."

The Public Rangelands Improvement Act (PRIA) of 1978 is the most recent legislation regarding fees for private grazing on federally owned land. Section 12(b) of this Act, requires "No later than December 31, 1985, the Secretaries (of Agriculture and Interior) shall report to the Congress...their evaluation of the fee established in Section 6...and other grazing fee options, and their recommendations to implement a grazing fee schedule for the 1986 and subsequent grazing years."

The current grazing fee formula, the PRIA formula, was established in this 1978 Act. The PRIA formula is a modification of the formula recommended in the last grazing fee study conducted by the Department of Agriculture, through the Forest Service (FS) and the Department of the Interior, through the Bureau of Land Management (BLM).

The Secretaries of Agriculture and Interior conducted a 1977 study (2)[2/] to comply with the Federal Land Policy and Management Act of 1976. At the conclusion of the 1977 study, the Secretaries recommended a fee based on the "fair market value" of $1.23 (and the private grazing land lease rate index).[3/]

However, in the debate surrounding the Congressionally established fee, it was argued that private grazing land lease rates do not respond quickly to changes in grazing resource returns caused by year-to-year fluctuations in livestock prices and rapid inflation in cost of purchased inputs(2). Therefore, two additional terms were combined with the formula to allow for

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2/. Numbers in parentheses refer to items in the Reference Section.
3/. Most references to this $1.23 base fee value refer to it as fair market value only in quotation marks. Hence, there is implicit agreement that this figure is fair market value by proclamation and not by defensible logic. Perhaps the biggest difficulty to the establishment of a true fair market value is the variability of range value among tracts and over time.

closer synchronization of fee adjustment with changes in the returns to the grazing resource.[4/] These terms involved livestock prices and an index of production costs.

The current fee formula, called PRIA, is:

	Index of		Index of		Index of	
Fee = $1.23 X	Private Grazing +	Beef	-	Production	- 100
	Land Lease Rates	Prices		Costs	

the indices are all based on a 5-year period with 1964-68 equals 100

This formula evolved through a great deal of debate and remains controversial not only in its general conception but in the details of how the indices are derived. This is reflected in House Report No. 95-1122, "Improving the Range Conditions of Public Grazing Lands," where the House Committee on the Interior and Insular Affairs, acknowledged and responded to the controversy in the following passage:

> "The Committee is aware, however, that many groups and individuals concerned with the improvement of the range disagree with the concept of pegging grazing fees to beef prices and the ranchers' ability to pay, and do not believe lower fees will eliminate overgrazing.... To accommodate these concerns, the Committee agreed to put its formula on a 7-year trial basis only, from 1979 to 1985. This 7-year trial period will give all sides an opportunity to study the effects of tying the fee to beef prices, and also allow the Secretaries to refine their data on the value of Federal grazing lands as compared to privately owned lands."

4/. This was categorized as an "ability to pay" adjustment in the fee discussion rather than an adjustment for changes in grazing resource returns. Certainly "ability to pay" is affected by changes in net resource returns, however, in economic terms, resources "earn" more or less as product prices vary.

This is a most curious passage; it implies that some groups believe that lower fees might eliminate overgrazing or that high fees might lead to overgrazing. The economics literature indicates that economic incentives to overgraze are due to (a) low fees, which allow grazing at a profit, even when the value of grazing becomes very low (30) and/or (b) property right indefiniteness (8, pp. 141-2). Property right indefiniteness tends to make natural resources fugitive in character and stimulates intensive present use. The lesson of this is that overgrazing is not caused by high fees. Nor are low fees a problem when security of long term use is assured.[5]

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5. Some of the examples of important fugitive resources cited include..."wildlife in the United States, migratory waterfowl, high-seas fisheries, and range forage on the public domain before the Taylor Grazing Act...."

PART II. THEORETICAL AND EMPIRICAL BACKGROUND

The fundamental problem involved with public grazing is the development of a "fair" price given the interests of the parties involved. Ordinarily, such a price would arise in a marketplace. However, in this case, there is no market, rather, grazing rights are allocated and priced by the government under explicit restrictions prohibiting a market from arising. Thus, the basic problem involves setting a price for a nonmarketed commodity. (Obermiller (28) argues this point at length). In turn, this problem leads to two important subproblems. The first involves determination of the price, which would arise under a market. The second involves the implications of the choices of alternative prices for economic performance.

Three major complicating attributes of the allocation and fee problem which make it complex are (1) the many complex uses of public range, (2) the variable productivity, not only of the land itself, but of the forage too, as measured by animal unit months of grazing on the public range, and (3) the year-to-year variability of the returns to grazing due to fluctuating prices for inputs and outputs.

In addition to private grazing of cattle, sheep, and horses, public grazing lands are used for the production of timber for lumber, other wood products, and firewood; for watershed protection, for the reduction of flooding, and soil erosion; for the protection of riparian zones; for water production for irrigation, municipal water and power; for production of wildlife; for recreation including hunting of big game and upland game, hiking, camping, fishing, birdwatching, etc.; and for mining of minerals and energy to name the more important. Thus, the fee problem has important dimensions in terms of the effects on other uses.

A number of issues regarding grazing fees are discussed below. These deal with several important considerations. First, we discuss the background to the basic nonmarket valuation problem and related economic performance issues. We then turn our attention to microeconomics of grazing where we deal with the value of grazing, the allocation among uses, allocation among users, rate of investment, the consequences of various fee levels and the effects of uncertainty. We then present data on variability in forage values among parcels. Subsequently, we deal with the welfare implications of the present system and possible fee system changes.

Valuation of Nonmarketed Goods

Economists have approached the problem of price determination for goods not traded in the marketplace in a number of different ways. A marketlike price of a good may be estimated by studying its consequences in terms of observed economic behavior, by questioning individuals relative to the value of the good, or by synthesizing the value utilizing some sort of an economic model. Each of these potential approaches has been reflected in the grazing fee arena. Valuation from observed economic behavior could be developed by observations in a related market; i.e., one could utilize private land lease rates to set fees for public land. Here the assumption would need to be made that the characteristics of the grazing in the private land market are identical to those of grazing on public lands. Alternatively adjustments could be made to develop public lease rates by "appropriately" adjusting private land fees (PRIA and the other formulas using the private land lease rate constitute such an attempt). The value of grazing fees could also be observed by looking at the consequences as reflected in the value of the base property values arising due to public land access. In this case, one would assume that the excess between the demand schedule and the grazing fee was capitalized in the base property (i.e., the permit value).

Proposals have also been made to determine the value of grazing land through elicited responses. Such suggestions commonly involve questioning procedures such as bidding games or contingent valuation (Freeman (9)). The institution of competitive bidding procedures could also fall into this category. The use of either bidding or bidding games would require care so that systematic bias is not introduced due to lack of information, limited competition or strategic behavior.

The third conceptual approach would involve inference of a fee based on an economic model. Here approaches such as simple budgeting could be used where the fee would be equated to residual value of land. At the other end of the spectrum, more complex analyses could be done using a firm linear programming model where the fee is equated to the shadow price schedules. Here one needs to be careful that the model is valid.

Efficiency and Equity

There are two fundamental economic performance measures which can vary when altering fees and/or policy for private grazing on federal lands. First, the realignment of federal grazing land policy may alter the use efficiency of grazing resource both among competing uses and firms and between current and future time periods. Second, grazing policy may alter the distribution of economic gains from the use of federal range, i.e., the equity of the parties involved.

The idea of economic efficiency is expressed in its simplest form by Haveman (15, p. 7):

> "Economic efficiency is achieved when the value of what is produced by any set of resources exceeds by as much as possible the value of the resources used; or when the least valuable set of resources is utilized in producing any worthwhile output."

Economic efficiency ideally would result in the greatest net social benefit or welfare. Calculation of efficiency involves the benefits and costs associated with the grazing use and the other various uses. Nonmarket amenities and services, as well as marketable products, must be counted. The economic portion of the objectives of policy and management that involve maximization of the net social returns to the publicly held resource imply a desire to attain the efficient state of usage.[1/]

Equity refers to fairness, impartiality, and justice in the distribution of net social benefits accruing; in this case, from the allocations of federal grazing lands among uses and users. Equity arguments have also been made in

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1/ Net social returns are defined as economic benefits to society minus the costs to society of achieving these benefits.

terms of local community impacts. We do not discuss these here as (1) they are not relevant from the standpoint of national efficiency analysis (Stovener and Kraynick (32)); (2) they are discussed in two companion papers (Brokken and Radtke (4), (5)). It is generally thought that it is equitable for ranchers to pay a fee equal to the full value of forage. Theoretically, this is the fee (price) that would emerge in a free market economy. The main equity issue has focussed on the distribution of income between private users, private nonusers, and the government. This issue has become complex because a large part of the difference between the value of the forage and the fees collected has been capitalized into the base ranch, i.e., "permit value". Over the last 50 years, many properties have been transferred to new owners who have purchased the permit value. Fee increases may result in a capital loss for these permit holders. This tends to reduce differences in the equity position of ranchers with and without public land access in that those with public lands have incorporated higher costs into their operation by paying for the capitalized difference between the fee and grazing value in acquiring the base property (buying the permit value).

If federal range is not now allocated efficiently, then, for efficiency to increase, there must be a reallocation among uses, users, or time periods. For example, an increase in fees that does not result in a change in utilization has no effect on efficiency. Equity in the distribution of net benefits from grazing is not a necessary condition for efficiency. In some cases, fees can be increased and benefits thereby redistributed without affecting efficiency; in other cases, fee increases may result in decreased efficiency.

Individual Firm Analysis

The individual firm is the basic unit of micro economic analysis. Most économic analyses of grazing fees and public land management have focused on the individual firm or ranch as the basic party of interest. This section also focuses on the firm presenting three resource valuation concepts: marginal value product, factor demand and resource shadow price. Subsequently, we present the theoretical background on resource allocation decisions with regard to stocking rates, allocation of range to optional uses, and transfers of use rights among firms. This is followed by sections on the micro economic effects of fee alterations and on the effects of uncertainty in prices, yields, and costs, as manifest in the leasing market.

Marginal Value Product

Resources, are valued in terms of their physical productivity and the prices of the products produced. The marginal value product (MVP) of resource x used to produce product y is written as $MVP_{x,y}$. Formally, $MVP_{x,y}$ is: the marginal physical product of resource x when utilized in the production of y(MPP_x,y) times the price of y,(P_y). $MVP_{x,y} = MPP_{x,y} P_y$ 6/. The $MPP_{x,y}$ is the amount of output lost if one unit of input x taken is away while the use of all other inputs is held fixed. Marginal physical productivity can be calculated at any level or intensity of resource use. Thus, $MVP_{x,y}$ is the value in dollars attributable to the singular contribution of the last unit of resource x in the production of y.

6/. More precisely, in equilibrium, the resources are priced as the marginal productivity multiplied by the price of the last unit produced which is marginal revenue. This product is called value of marginal product VMP rather than MVP. Under pure competition average revenue for a firm is the same as marginal revenue which is the commodity price. Thus, VMP=MVP in perfect competition.

When successive units of input yield positive but smaller and smaller amounts of physical product, the total output is <u>increasing</u> at a decreasing--progressively slower--rate. When the MPP eventually becomes zero, total output is a maximum. No further increase in total output will be possible with the increase of x while other inputs are held constant. At maximum output MPP, becomes zero; i.e., another unit of input does not yield any further output, the corresponding MVP is zero and total revenue maximized. Profits are maximized when all units of resource that yield returns greater than the resource cost have been used. Hence, economic efficiency is obtained when the resource is used to the point that MVP equals the cost (price) per unit of the resource x, P_x : $MVP_{x,y} = P_x$.

This is the basic condition that assures economic efficiency of resource use. If the resource MVP equals the resource price in all uses within and between firms, then resources are efficiently allocated among uses. However, in the case of limited availability of an input or resource, the absence of this condition does not necessarily mean that the resource use will be inefficient. In fact, under a fixed allocation system, efficiency will be attained only if the usage stimulated by the allocation and fee equals the amount which would occur if the MVP equaled the price of the input.

It should be noted that the MPP of any particular input depends on the quantities of the other inputs. In turn, the quantity of the other inputs which are used depends on all input and output prices. Thus, if the prices of some inputs change relative to the price of other inputs, the optimal (profit maximizing) combination of inputs may change. This would affect the MPP schedule and therefore the MVP schedule of any or all inputs. A more general approach is given in the factor demand section which is next.

Factor Demand—Multiple Factors

A second construct for the derivation of firm factor prices involves the concept of factor demand. The MVP concept discussed above is appropriate and equal to the firms demand curve in the single factor case. However, in a multiple factor case, one should use the factor demand curve capturing both the increased output and factor interrelationship effects. This concept does not merit a great deal more discussion, although it should be stated that factor demand is a function of the prices of other factors, the price of output and the quantities of any fixed factors. Factor demand is a generalization of the MVP concept above. In this case, efficiency is realized when the factor is priced on the basis of the factor demand curve.

Resource Shadow Prices Estimated by Linear Programming

A third valuation method which has played a role historically in the grazing fee debate and which is the basis for a proposed fee system is the shadow price. A resource shadow price is a concept similar to marginal value product or product demand. Shadow prices give estimates of the imputed values on the margin of the various limiting resources which confront the production process. One way of developing such estimates is through the use of specially formulated linear programming models of the firm's production possibilities. In such models, the dual variables are shadow prices representative of imputed

market place prices for the resources. The dual variable of a particular scarce resource indicates the marginal amount by which a profit maximizing objective function (net returns) would decrease if one less unit of the resource were available. This is different from an MVP in a strict theoretical sense, because the utilization of other inputs to the production process may change in the linear programming solution whereas they are held constant in an MVP. Thus, this concept is closer to that of factor demand. The value of the dual variable is affected by the product price, the average physical product of the input and the prices of the various inputs.

Roberts' Analysis

Roberts (30) presented an analysis of the grazing fee situation in 1963 using the MVP concept. Roberts proposed a relationship between the MVP for grazing and the stocking rate (measured by the number of cows on a parcel) as shown in figure 1. He also cites empirical evidence for the shape exhibited in the figure. Roberts' MVP curve is constant from zero up to q_o cows per section. After q_o, the MVP declines at an increasing rate to zero. Since MVP is the product price multiplied by marginal physical product, zero MVP also corresponds to zero marginal physical product or to (short term) maximum total product per section.

In figure 1, short run marginal factor cost per cow (MFC) includes nonfee operating costs, A, and grazing fees, B minus A. If the MFC of grazing per cow is constant as shown in figure 1, the short run profit maximizing stocking rate is q_3. This is the stocking rate corresponding to the intersection of MVP with resource cost (MFC).

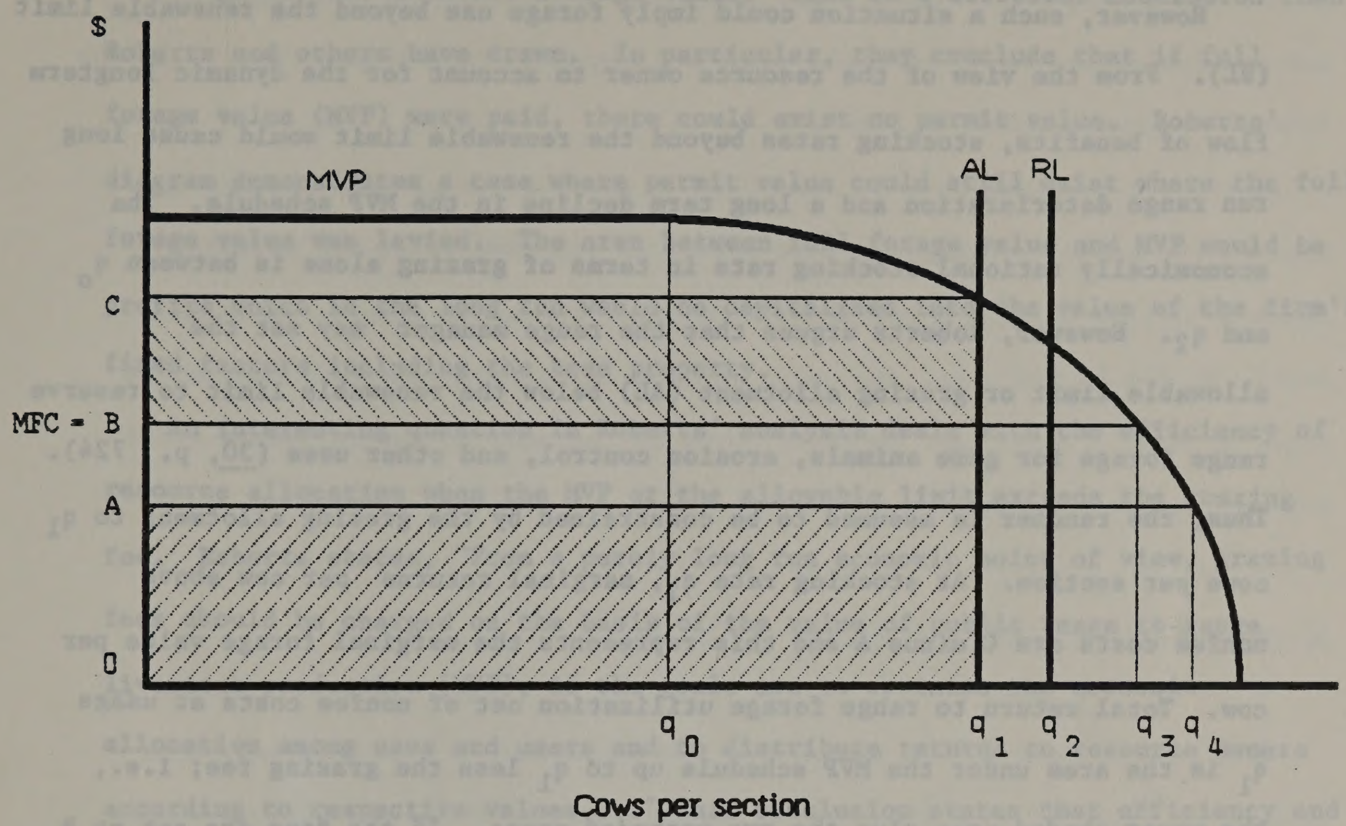

Figure 1. Marginal Value Products and Marginal Factor Cost Functions and The Stocking Limits Associated with Variable Stocking of a Seasonal Range of Given Quality.

However, such a situation could imply forage use beyond the renewable limit (RL). From the view of the resource owner to account for the dynamic longterm flow of benefits, stocking rates beyond the renewable limit would cause long run range deterioration and a long term decline in the MVP schedule. The economically rational stocking rate in terms of grazing alone is between q_o and q_2. However, Roberts argues that the range manager may set the allowable limit or grazing allotment (AL) below the renewable limit to reserve range forage for game animals, erosion control, and other uses (30, p. 724). Thus, the rancher is assumed to be constrained by the grazing allotment to q_1 cows per section. At stocking rate q_1, marginal returns per cow above nonfee costs are C minus A and this represents the marginal forage value per cow. Total return to range forage utilization net of nonfee costs at usage q_1 is the area under the MVP schedule up to q_1 less the grazing fee; i.e., the upper shaded area plus the two unshaded areas. If the fees are set at B minus A per cow, the total return would be the upper shaded area plus the upper unshaded area. If the fee were set at the MVP, the fee per cow is C minus A and the total fee receipts per section is the upper shaded area plus the lower unshaded area.

This would still a leave return to the permittee in the amount of the upper unshaded area which, under a long term lease, might be capitalized into permit value even though full forage value was paid in fees. This, of course, would result anytime the range usage falls in the region of declining MVP with average value product higher than marginal value product. For the area from 0 to q_o, charging full forage value (MPV) would eliminate possible capitalization as Average Value products equal to Marginal Value Product. As

MVP becomes less than AVP then there is benefit to be capitalized as the price of forage is less than its average value. This is a different conclusion than Roberts and others have drawn. In particular, they conclude that if full forage value (MVP) were paid, there could exist no permit value. Roberts' diagram demonstrates a case where permit value could still exist where the full forage value was levied. The area between full forage value and MVP would be profits which in the long run would be capitalized into the value of the firm's fixed factors including the base property.

An interesting question in Roberts' analysis deals with the efficiency of resource allocation when the MVP at the allowable limit exceeds the grazing fee. Roberts states, "From a purely long run economic point of view, grazing fees should be charged on the basis of the value of public range to range livestock production (MVP), if the goals are to optimize the economic allocation among uses and users and to distribute returns to resource owners according to respective values...." This conclusion states that efficiency and equity are at issue. The efficiency part of the statement deserves close analysis.

Within Roberts' analytical framework, an increase in the grazing fee from AB to AC (increasing MFC to full MVP) does not suggest a change in utilization and, therefore, no change in economic efficiency occurs (assuming other input levels remain unchanged). Thus, Roberts assertion that range should be priced according to its MVP for grazing will not necessarily increase long run economic efficiency are currently below MVP. Efficiency is not affected. Utilization remains at the allowable limit, q_1. Total net returns to grazing remain unchanged. Gardner (<u>10</u>, p.118) acknowledges this point stating, "The annual fee per AUM collected could be set at any level below the value of

marginal product of the grazing. If set at the value of marginal product, the permit would have zero value." This assumes a production function that is homogeneous of degree 1 (constant returns to scale) which differs somewhat from Roberts' argument shown in figure 1.

Thus, the stocking rate is set at q_1, a grazing fee of C-A will maximize fees to the resource manager. This result is achieved given the allowable limit at q_1, by setting a fee at AC, the point where MVP equals resource cost. In the latter case, the user, seeking to maximize profits, chooses to stock at rate q_1 cows per section, which is the same as the allowable limit set by the public rangeland manager.

Allocating Range Forage Among Uses

The basic framework for optimizing the allocation of range forage among species is provided by Hopkin (16). Hopkin dealt with the allocation between cattle and sheep. Figure 2 shows the physical substitution relationship between sheep and cattle in grazing a specific tract of land. This figure was developed by Hopkin (16) based on data from Cook (7) showing allowable simultaneous stocking rates for sheep and cattle when both utilize a specific tract of land. Cook originally estimated only linear substitution rates (the two straight lines meeting at point R in figure 2). Hopkin fit the curved line, justifying its shape on the basis of theoretical considerations and empirical evidence. If the efficiency of combinations of sheep and cattle were the same as the efficiencies when either all cattle or all sheep were grazing, the physical substitution line would be the straight line labeled curve E. The difference between curve F and curve E represents the potential physical efficiency gains from grazing mixed species (in this case, cattle and sheep).

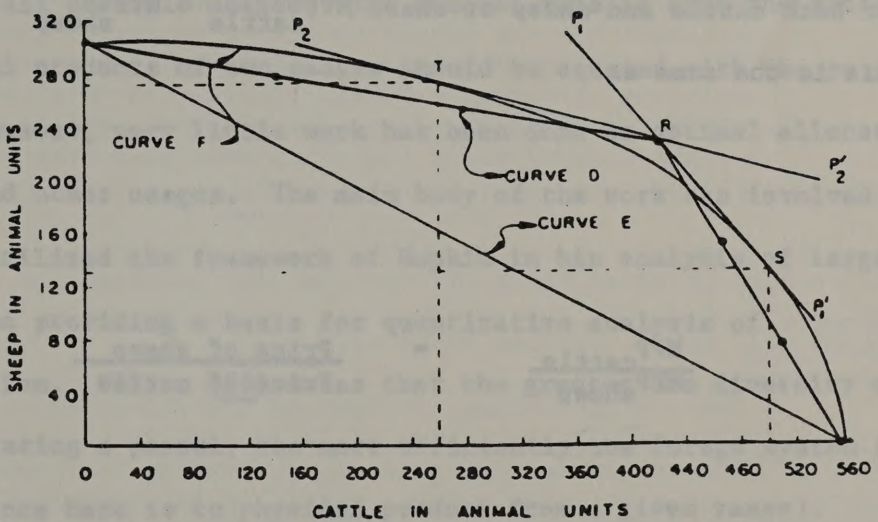

Figure 2. Combinations of sheep and cattle on 2,800 acres of range land in the Wasatch Mountains and optimum use for selected price relationships of sheep and cattle

Notice that starting with all cattle, the addition of sheep to the range has a small effect on the number of cattle that can be grazed. However, as more and more sheep are added, the competition with cattle is more pronounced with the curve becoming flatter. Throughout the curve, progressively more cattle must be taken off the range for each unit of sheep added. The same phenomenon occurs, if one starts with all sheep and adds progressively more cattle.

The revenue maximizing allocation of the range between sheep and cattle depends on their relative prices. The revenue maximizing allocation between cattle and sheep occurs where the marginal value products of range is equated for both cattle and sheep or where $MVP_{cattle} = MVP_{sheep}$. In MPP terms, this is the same as:

$$\frac{MPP_{cattle}}{MPP_{sheep}} = \frac{\text{Price of sheep}}{\text{Price of cattle}}$$

that is, in figure 2, revenue is maximized where the slope of the physical trade-off curve (the marginal rate of substitution of cattle for sheep) is

equal to the slope of the price line (the ratio of the price of sheep to the price of cattle). If the physical productivity curve remains stable, the optimal stocking rates of cattle and sheep depend on their relative prices.

Two different price ratios are used to illustrate the revenue maximizing mix of cattle and sheep in figure 2, line P_2P_2' and line P_1P_1'. If the price ratio is the slope of line P_2P_2', total revenue is maximized with the mix of cattle and sheep shown at point T in figure 2. If the price line is P_1P_1', then the optimal mix is at point S.

The cattle-sheep trade-off is illustrative of the problem of allocating public forage among all possible usages. The general rule is that the ratio of the marginal plysical products of two usages should be equated with the ratio of net revenues. However, very little work has been done on optimal allocation between livestock and other usages. The main body of the work has involved game. Nelson (26) utilized the framework of Hopkin in his analysis of large herbivore competition providing a basis for quantitative analysis of interspecies allocation. Nelson (26) notes that the greater the diversity of herbivore species grazing a parcel, the more efficiently the forage system is utilized (the reference here is to physical product from a given range).

Alternative usages may also be complementary. That is, increasing one usage may also permit increasing another usage. Managers of the winter elk range on the Bridge Creek Wildlife Management area located in Northeastern Oregon have found complementary relationships between cattle grazing and winter elk grazing. The carrying capacity for winter grazing of elk has been found to be increased by carefully managed limited grazing of cattle in other seasons of the year (1). Further international evidence (26) (13) shows that the highest grazing productivity exists in East Africa because of the great diversity of species in the grazing population.

The framework, proposed by Hopkin, as utilized by Nelson (26), is a method of expressing efficiency in monetary rather than physical terms. However, utilizing this framework would be very difficult. Very limited data exist on rates of substitution between domestic livestock and wildlife with those data that exist being quite site specific as Nelson recognizes. This is reinforced by Martin who states:

> "We certainly have no idea of the marginal rate of substitution between multiple products that may be produced on the range in addition to domestic livestock. Most work on the economics of range improvement came to a close in 1964 when Western Regional Project W-16, Economics of Rangeland Improvement, first approved in 1953, submitted its termination report. As I stated in my 1971 Comment on Burt's Dynamic Economic Model of Pasture and Range Investments, we agricultural economists finally quit most work on the problem, when it became evident that no consistent set of empirical data was available--or was likely to become available--with which to work. In 1967, Dicherman and I in a desperate attempt to produce at least something, produced a fairly simple conceptual model for which we could find no usable data. Burt's 1971 article completed the era with a sophisticated model for which even less data were available." (23, p.6)

The lack of physical trade-off data is also confirmed by wildlife biologists. Nelson (25) notes, quoting Mackie (22 p.49),

> "What is surprising, in view of the widespread attention given interspecific relations of large herbivores...is that remarkably few firm conclusions of general application have emerged. Much of our current thinking remains rooted in inference and speculation and is controversial at best."

Several studies have been undertaken to determine the value of wildlife and wildlife recreation including studies by Brown, et. al. (6), Martin, Tinney, and Gum (24), and Sandrey (31). The value of another elk has been estimated, however, it is not known how many, if any more, elk might be expected from the reduction of grazing by domestic animals.[7/] Nor is any thing known about

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7. For an excellent review of literature on values of wildlife, see Loomis, and Sorge. (21) the technical/biological trade-off relationships between livestock and other recreation and wildlife uses but for a very few sites.

There is potential for increased economic efficiency through reallocation of range between domestic livestock and other uses including wildlife, recreation, and soil conservation but data needed for determining such reallocations are not generally available. There is also a potential difference in the social value of certain range usages between private and public parties.

Land allocation between alternate uses could be quite different under the public management than under private management. For example, most benefits to water conservation accrue off-site while costs, including opportunity costs from reduced grazing, accrue on site. Consequently, the total social benefits to water conservation would not accrue to the individuals who bear the cost. And, in the absence of social compensation, the allocation of rangeland to water conservation or a member of other uses might not be socially optimal.

The greatest difference in resource allocation between private and public management may be in allocations to recreation. Under public ownership and management, recreation on the Forest Service and BLM lands is open to anyone. The cost above travel cost of gaining access to the many Forest Service or BLM parcels is essentially zero. Under private ownership or private management, cost for negotiating the right to entry could become prohibitive, even if no fee were charged. Current benefits from recreation are large: for example, see Loomis and Sorg (21). The cost incurred by private holders for negotiating the trespass rights would need to be deducted in arriving at the loss to recreation benefits. Thus, the net benefits for nongrazing uses might be much lower under private ownership than under public ownership.

Allocation Among Ranchers

Theoretically, in markets for freely tradeable goods, resources are used by the individuals who obtain the highest marginal value products from their use. However, federal grazing lands are subject to transfer restrictions. Gardner (10, p. 113) dealt with this issue citing evidence that public range was underpriced, stating:

> "The evidence indicating misallocation is substantially the following: (1) Historically, the BLM and forest fees often have been below the value of the marginal product of public grazing. (2) If transfer of permits were unrestricted, the differential between the fee and the value of the marginal product of grazing would get capitalized into permit values, assuming perfect competition in the market for permits, certainty of grazing tenure, and no capital rationing. (3) In fact, however, the actual permit values are less than the capitalized differential; it seems unlikely that uncertain grazing tenure, market imperfections or capital rationing can explain the disparity. The conclusion is that transfer restrictions (the nonprice rules and prerequisites for obtaining permits) could be preventing public grazing from moving to ranchers who would acquire these services if permits were freely transferable and market allocated."

One simple way to mitigate the inefficiency from misallocation among ranchers would be to encourage subleasing. If the permittee were charged a small fee for the right to sublease, all parties--the public landowner, the permittees, and the subleasee--could be better off. In regard to subleasing, Brewer (3, p. 42) states:

> "More efficient operators than the permittees presumably would respond to profit stimuli and initiate such transfers. The current permittee is then in a position of having secured a federal 'concession' at advantageous cost, redistributing income in a fashion favorable to himself. There still may be social objection to this, but the issue would then be one of income distribution rather than efficiency."

It is not clear why the permittee would not also respond to the profit stimuli and initiate such transfers himself.

Range Investments

The third major efficiency issue involves the rate of investment in rangeland improvement over time. The problem of efficient investment involves decisions about range depletion, conservation, and enhancement. The optimum in all cases involves obtaining the maximum net present value from the range resource or from conservation and range improvement investments.

Both uncertainty of tenure and fee levels have consequences for range investment. Investments ordinarily are made when the net present value of benefits exceeds the net present value of costs. However, in the grazing lands situation, the lands are not owned by the user; thus, the investment situation involves decisions by both the government and the land user. Given that the thrust of this manuscript involves governmental policy on fees, the private investment decision will not be analyzed. (Nevertheless, under any leasing arrangement, particularly a short term one, tenure insecurity would influence the private rate of investment.)

Government fee and range investment policy do have efficiency dimensions. Historically, fees for range improvements have been returned to BLM districts or forests from which they were collected. Benefits from many range improvement projects have been said to be "significantly" lower than the project costs (34). "Significantly," in this case, means an amount that cannot be dismissed by disagreements over proper discount rates; i.e., the range improvements cost more than they were worth over any reasonable range of rates.

The government will realize the greatest return from its investments, when it has invested in the best projects; that is, when the investments with greater net present value are given priority to those with lower net present value. Consequently, increased efficiency is more likely when wider

comparisons among projects are utilized in the project selection process. Currently, range improvement funds are returned for allocation among projects within forests, or BLM districts and then are allocated to projects in specific parcels. This is efficient only if the highest valued investments were distributed in the same systematic manner as the investment funds. Under strict adherence to efficiency criteria, there is no guarantee that funds would be returned even to the forest district from which they were collected. Enhanced economic efficiency might be achieved through a more comprehensive investment appraisal procedure.

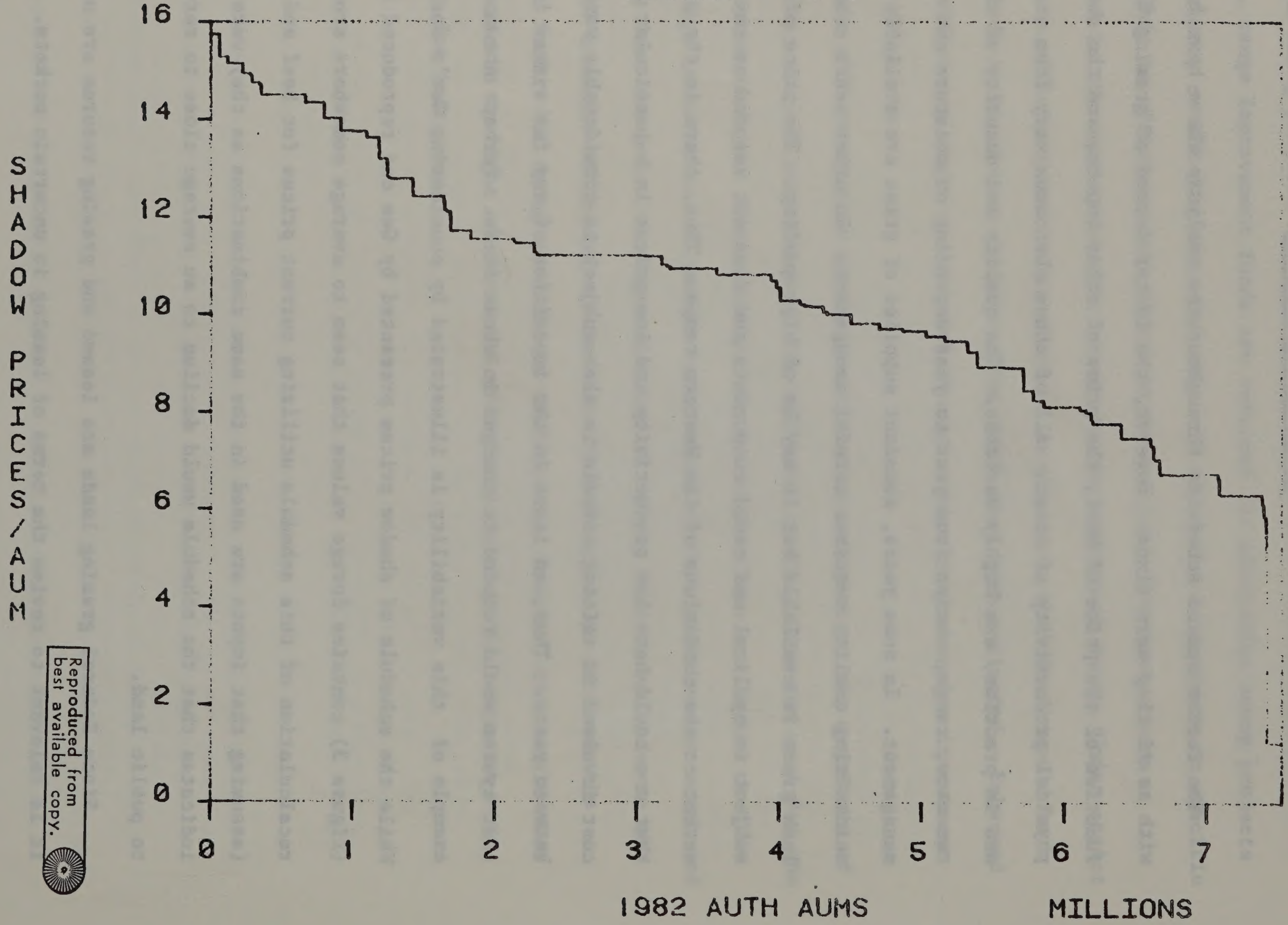
Economic efficiency also enters the situation relative to the magnitude of grazing fees, since a proportion of the collected grazing fees are used for the range improvement fund. Consequently, the fee collections are linked to the rate of range investments. If public investments exhibit positive net worth and if grazing fees are below the imputed value of range, then it would be in the interest of economic efficiency to increase fees in order to increase the investment fund. Not doing so would be inefficient. However, this would need to be considered in light of decreased efficiency, such as if range use were reduced by fee increases.

Risk and Uncertainty

The factor demand schedules throughout the analysis above have been dealt with as if they were fixed. However, the factor demand of grazing is a function of the price of beef, the price of other inputs, and the marginal physical productivity of range. All of these phenomena vary from year to year and in practice, are highly variable. The quality and quantity of the physical resource, range, varies from year to year depending on moisture and management. In some years, abundant supplies of grass are available, but maintaining quality requires careful management. In other years considerably less grass is available but it may be of high quality. The price of beef is subject to cyclical and trend components and does not respond at any great extent to the conditions of the Western range. Thus, there is the possibility that one could have low productivity and low prices in a particular year. The cost involved in raising animals is also subject to considerable variability between years. Thus, an issue in the imposition of any fee system involves how that system would respond to changes in these items. Perhaps the most striking example of this variability is illustrated by considering Gee's analysis. While the schedule of shadow prices presented by Gee and reproduced below (figure 3) contains forage values that seem to average somewhere around $10, a recalculation of this schedule utilizing current prices for beef and inputs (assuming that inputs are used in the same combinations as they were then) indicates that the schedule would decline to an average close to zero or return to public land.

Since Federal grazing lands are leased and grazing returns are uncertain, it is relevant to review the terms of leasing in uncertain markets. The

Figure 3. SHADOW PRICES AND CUMULATIVE AUMS
REGION 1 TO 6



leasing of farms and ranches by owners to others has long been a prominent practice. Approximately 80 percent of the farms involve leased land while 30 percent of U.S. lands are leased (29, p. 19). Only 44 percent of all rented farms are classified as cash leases, another 16 percent have combined cash and share leases. Thus, 56 percent of the rented farms have a share arrangement wherein the revenues and costs are shared between the landlord and tenant (35). The underlying reason for share leases seems to be risk sharing (29).

The main concern in risk sharing is with the level of risk in relation to ability to pay fees without firms becoming insolvent. The extent to which this is an important factor in setting lease rates on private grazing lands is not known. Further, it would be difficult to apply on public lands. Ideally, the lease rates should be less than the average imputed prices by the risk premium. No doubt the risk aspects vary among tracts of federal grazing lands. Forage quality and production varies geographically and over time even within an individual forest or BLM district. For example, the Wallowa Whitman National Forest extends approximately 80 miles north and south, 80 miles east and west; grazing extends from about 3,000 feet in elevation to 7,000 feet; annual average precipitation varies from 15 inches in some parts of the forest to above 50 inches in other parts. It is unlikely that the assumption of a standard risk discount would apply equally over all grazing tracts in the 11 Western states.

If strict adherence to collection of full forage value annually were a goal, some kind of parcel-by-parcel consideration of risk (perhaps a share lease) would need to be developed. Under such a lease, negative returns could occur in some years, while high returns would occur in other years.

Empirical Evidence of Variable Forage Value and Productivity

Much of the dialogue, analysis, and policy regarding grazing fees seems to be based on the assumption that an AUM is a unit of homogeneous productivity across all grazing lands in the West, if not in the United States. Perhaps this dates back to the late 1950's and early 1960's to evidence developed by Gardner (11, p. 52, note 4) who stated:

> "...Apparently the extreme variation in per acre rents washes out when the AUM (which is a quantity of forage) becomes the grazing unit. This evidence suggests that all AUM's can be assumed to be homogeneous with respect to grazing quality without too much violence to the facts."

This finding was based on a survey of rental rates on private range lands in Utah, Wyoming, Idaho, Arizona, and California. Certainly, the idea of homogeneity of AUM's across the public grazing land in the West is also implicit in the definition of fair market value developed by the 1968 Technical Committee, Chaired by Houseman, et al. (17)

> "...'Fair Market Value' is defined as the difference between total costs of operating on private leased grazing lands and total nonfee costs of operating on National Forest System lands. These costs include lost animals, veterinary services, moving livestock to and

from permitted areas, water, horses, fence, and water maintenance, development depreciation and other miscellaneous costs. The private costs also include the private lease rates..."[8]

However, the 1968 Technical Committee report also notes that data on costs of grazing on federal land show considerable variation in costs and value per AUM. Houseman, et al. (17) reporting on the 1966 Survey indicated that:[9]

"Variation among individual allotments of grazing cost per AUM was very large within every category studied; namely, ranching area; season of use, and size of permit or lease. The strongest relationship found was the tendency for grazing cost to decrease as the size of the allotment increased. Other relationships might have existed but could not be firmly established because of large random variation in the data. <u>The wide variation of grazing cost among individual allotments should be interpreted as a reflection of actual situation and not as an indication of inaccurate data</u> (Emphasis by the Authors). Differences among ranching areas, as shown by the data, were not large enough in relation to the wide variation that existed within areas to provide a basis for recommending differential base fee among ranching areas."

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8. Notice that there are quotation marks around the term Fair Market Value indicating that the definition does not fit the term.

9. These quotes are taken from the 1977 Study of Fees for Grazing Livestock on Federal Lands," (2, p. C-28).

Note that Houseman et al. do not state that differences among ranching areas are not large. They state that differences among ranching areas are not large in relation to differences within ranching areas. Moreover, they emphasize that the differences among individual allotments should be interpreted as the actual situation and not as an indication of inaccurate data.

Empirical evidence seems to suggest that the AUM value of grazing lands is not homogeneous across parcels. An analysis of Gee's results demonstrates this point. Gee (12) provides shadow price estimates for an average value of grazing for each forest in each of the ten forest regions [10/]. These have been reorganized and ranked in descending order of grazing value per AUM for each forest irrespective of the region in Figure 3. Figure 3 shows a schedule of the shadow price per AUM where the steps represent different forests. The horizontal segment corresponds to the number of authorized AUM's in 1982 for a particular forest. These are accumulated in order of descending grazing value per AUM over all forests in forest regions 1 through 6. Figure 3 shows that the variation in the value of an AUM of grazing is substantial.

Data obtained from the Statistical Reporting Service (SRS) of the U.S. Department of Agriculture also provide evidence of variable forage values within and across states in the summary of the 1982 June enumerative survey of private nonirrigated grazing land lease rates. These are shown in tables

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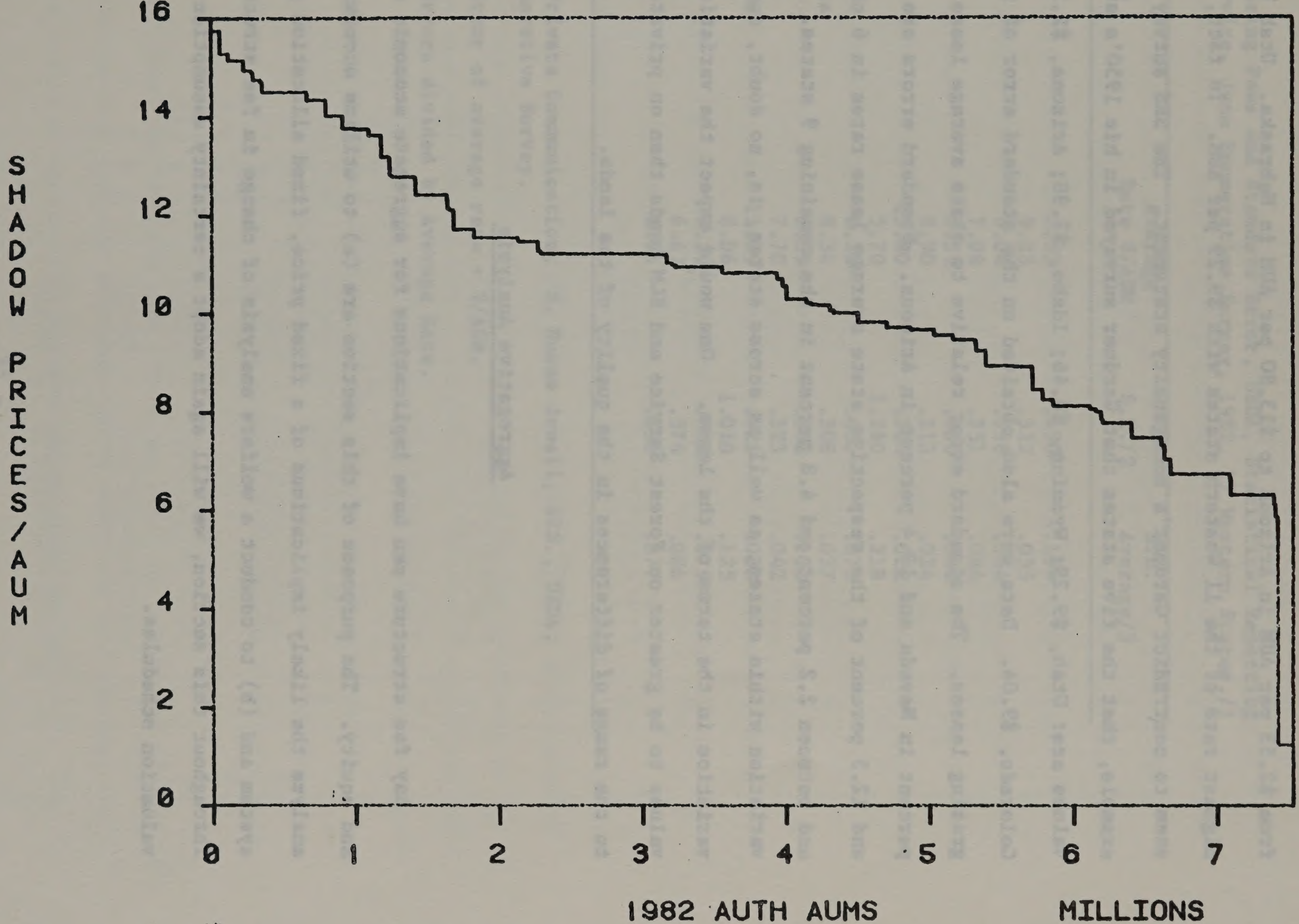
10/. The method for generating these shadow prices is discussed by Gee (12) but they do not appear in this reference. The shadow prices were provided by Gee in January 1983.

Figure 3. SHADOW PRICES AND CUMULATIVE AUMS
REGION 1 TO 6



1 and 2. The range in state average lease rates among the 17 Western states is from $2.53 per AUM in Arizona to $13.80 per AUM in Nebraska. Utah has the highest rate of the 11 Western states with $9.29 per AUM. In fact, the data seem to contradict Gardner's homogeneity statement. The SRS survey shows, for example, that the five states that Gardner surveyed in his 1950's study, the values are: Utah, $9.29; Wyoming, $8.46; Idaho, $7.98; Arizona, $2.53; and Colorado, $9.04. Data were also obtained on the standard error of private grazing leases. The standard error relative to state average lease is 21.8 percent in Nevada and 19.4 percent in Arizona. Standard errors are between 7 and 12.5 percent of the respective state average lease rates in 6 of the states and between 2.2 percent and 4.8 percent in the remaining 9 states. Some of the variation within states, as well as across states, is, no doubt, due to variation in the terms of the lease. One would expect the variation in forage values to be greater on Forest Service and BLM lands than on private land, due to the range of differences in the quality of the lands.

Aggregative Analysis

Any fee structure can have implications for aggregate economic efficiency and equity. The purposes of this section are (a) to utilize economic theory to analyze the likely implications of a fixed price, fixed allocation grazing fee system and (b) to conduct a welfare analysis of change in fee structure. Throughout this section, we will again adopt a certainty assumption regarding valuation schedules.

Table 1. Grazing Fees and Standard Error, USDA, Statistical Reporting Service, June Enumerative Survey, 1982, 17 Western States./1

State	Average Rate $/AUM	S.E./2	S.E. Average/3
Arizona	2.53	.490	.194
California	9.23	.322	.035
Colorado	9.04	.398	.044
Idaho	7.98	.351	.044
Kansas	9.59	.460	.048
Montana	8.90	.213	.024
Nebraska	13.80	.304	.022
Nevada	5.70	1.240	.218
New Mexico	6.26	.456	.073
North Dakota	8.34	.308	.037
Oklahoma	6.29	.648	.103
Oregon	7.70	.323	.042
South Dakota	11.09	.421	.038
Texas	8.06	1.010	.125
Utah	9.29	.733	.079
Washington	6.67	.574	.086
Wyoming	8.46	.651	.077

1/ Source: Private Communication, E. Duane Jewell, SRS., USDA, June Enumerative Survey.

2/ Standard Error of average rate + $/AUM.

3/ Standard Errors divided by Average Rate.

Table 2. Grazing Fees --base data--used in computing annual adjustment index. Rate (dollars) per head for pasturing cattle on nonirrigated private grazing land.

	N. Dak.	S. Dak.	Neb.	Kansas	Okla.	Tex.	Idaho	Wyo.	Colo.	N. Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.
Year/1																	
1964	1.84	3.13	3.75	3.52	2.76	2.38	3.33	3.40	3.51	3.09	3.15	3.03	2.86	3.42	4.28	3.17	4.02
1965	1.94	3.16	3.89	3.54	2.84	2.35	3.25	3.68	3.70	3.42	3.16	3.14	2.87	3.51	4.00	2.98	4.02
1966	2.09	3.34	4.20	3.85	3.14	2.43	3.40	3.70	3.93	3.53	3.51	3.31	2.83	3.50	4.06	3.26	4.08
1967	2.10	3.72	4.35	3.99	3.05	3.38	3.47	3.73	4.05	3.37	3.74	3.59	2.84	3.66	N/A	3.32	3.93
1968	2.37	3.80	4.50	4.15	3.15	2.71	3.48	3.95	4.03	3.43	3.64	3.66	3.10	3.53	4.43	3.63	3.71
1969	2.38	3.76	4.76	4.28	3.52	2.76	3.50	4.04	4.03	3.47	3.67	3.71	2.91	3.64	4.43	3.62	3.95
1970	2.58	4.16	4.89	4.46	3.50	2.79	3.71	4.28	4.03	3.62	3.70	3.87	3.44	3.78	4.76	3.66	4.44
1971	2.61	4.22	4.90	4.35	3.67	3.04	3.79	4.28	4.23	3.40	3.61	4.03	2.78	4.05	4.32	3.63	4.44
1972	2.76	4.41	5.12	4.55	3.80	3.19	3.99	4.45	4.45	3.92	3.80	4.32	2.52	4.34	3.94	3.53	4.52
1973	3.00	4.69	5.78	4.97	4.23	4.12	4.41	4.98	5.11	4.10	4.20	4.82	2.79	4.81	4.36	3.91	4.72
1974	4.13	5.79	7.16	6.40	5.11	4.14	5.43	5.81	5.51	4.41	5.29	6.87	3.21	5.51	5.41	5.36	6.78
1975	4.17	6.22	8.04	6.56	4.38	3.72	6.55	6.27	5.71	4.94	5.11	7.03	4.60	5.76	5.62	6.04	5.54
1976	4.39	6.41	9.61	12.86	4.62	3.96	6.14	7.07	6.26	5.15	5.18	7.38	5.63	6.04	7.50	5.81	6.99
1977	4.49	8.91	9.77	11.97	5.43	4.58	6.20	7.06	6.11	5.83	5.26	7.28	4.90	6.88	8.21	5.83	5.81
Year/2																	
1978	5.56	9.21	10.23	9.11	5.67	4.27	6.43	8.09	7.26	5.94	6.64	7.79	3.42	5.73	4.10	6.67	8.07
1979	6.29	10.13	11.20	9.97	5.94	4.65	6.47	8.74	8.12	6.83	6.88	7.78	4.63	6.30	2.55	7.29	8.19
1980	6.35	11.79	11.96	9.16	4.17	7.06	6.61	8.37	8.26	4.50	7.56	9.07	4.54	5.78	6.19	7.39	8.80
1981	8.69	11.97	13.81	9.06	5.88	6.78	8.20	7.93	8.20	6.98	7.54	9.40	5.60	7.24	6.29	8.18	10.48
1982	8.34	11.09	13.80	9.59	6.29	8.06	7.98	8.46	9.04	6.26	7.70	8.90	2.53	9.29	5.70	6.67	9.23

1/ Data from General Farm Questionnaire.

2/ Data from June Enumerative Survey.

Source: ESS-Econ; work sheets reflects data as originally rounded. Will not agree with data published since 1975.

Implications of Current Allocation Scheme

Let us consider the aggregate efficiency and equity implications of a system which has fixed fees and fixed allotments, as regards to other usages. Consider a case in which there are only two usages for land: grazing and other. Assume that suitable national demand curves have been constructed for both and that a supply curve is developed based upon the marginal cost of supplying land to these two usages. Graphically, three such curves are as portrayed in figure 4. Assuming land may be freely allocated between these usages, we may construct the resulting solution using excess supply curve concepts as shown in figure 5.

Now, assume that the range manager sets the price per AUM at P. The ranchers will graze quantity Q_z, and the quantity $A-Q_z$ will be available for other uses. The national allocation of land to forage would be Q. A total of Q_z AUM's should be supplied to livestock grazing with $Q-Q_z$ AUM's supplied to other usages. Given adequate markets, this theoretical mechanism would depict the quantity of forage land to devote to grazing and nongrazing uses. This type of construction could also be used by the government in selling the allowable grazing limit. In practice, the demand curves for other usages are elusive and the situation reduces to a situation, such as in figure 6 where A is the allotment level, and P is the price of the good at that allotment (as discussed at length below). Given this situation, any fee less than P will not change land use and the price will be between P and zero with its level dependent on the bargaining power of the grazers versus the government. Thus, any fee less than P will not alter the efficiency of land in grazing since no more than the allotment can be used. In this setting, the appropriate fee is an equity issue between the supplier and demander. This is

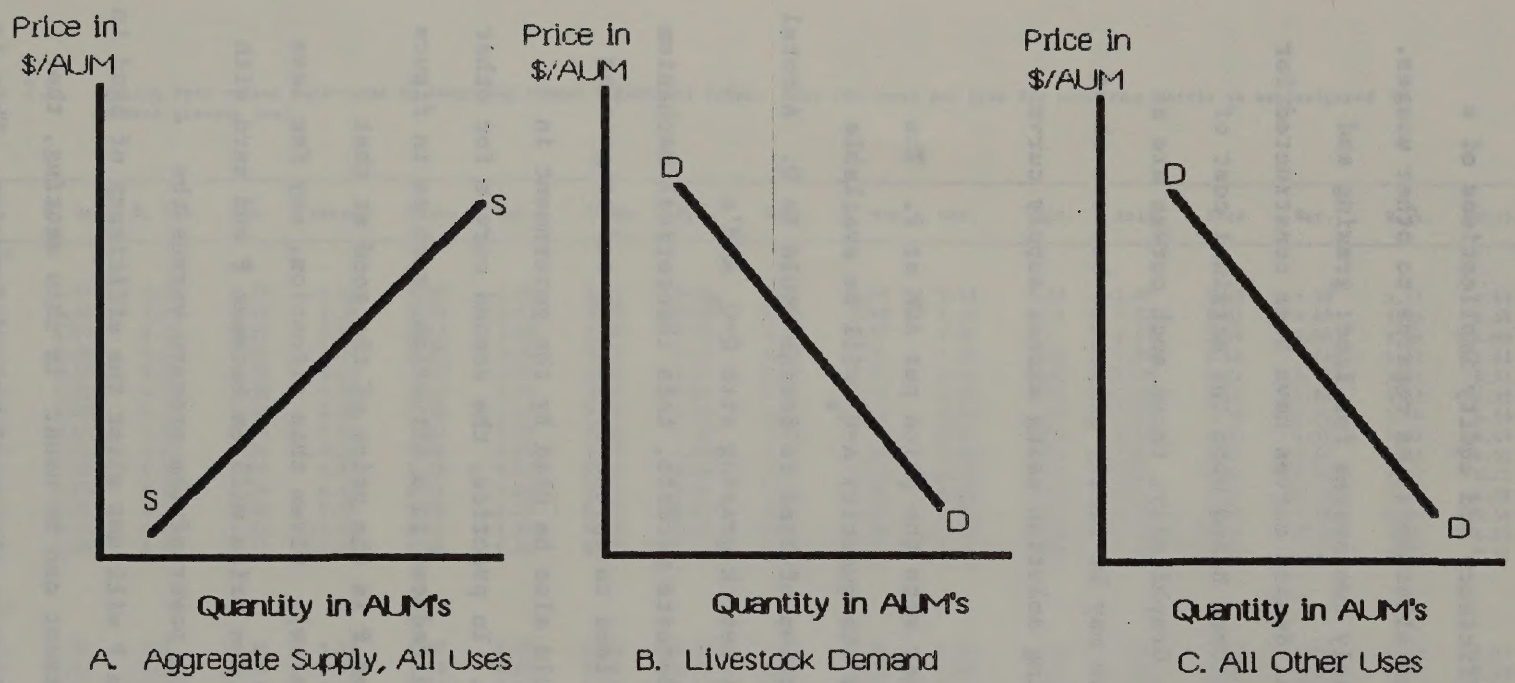
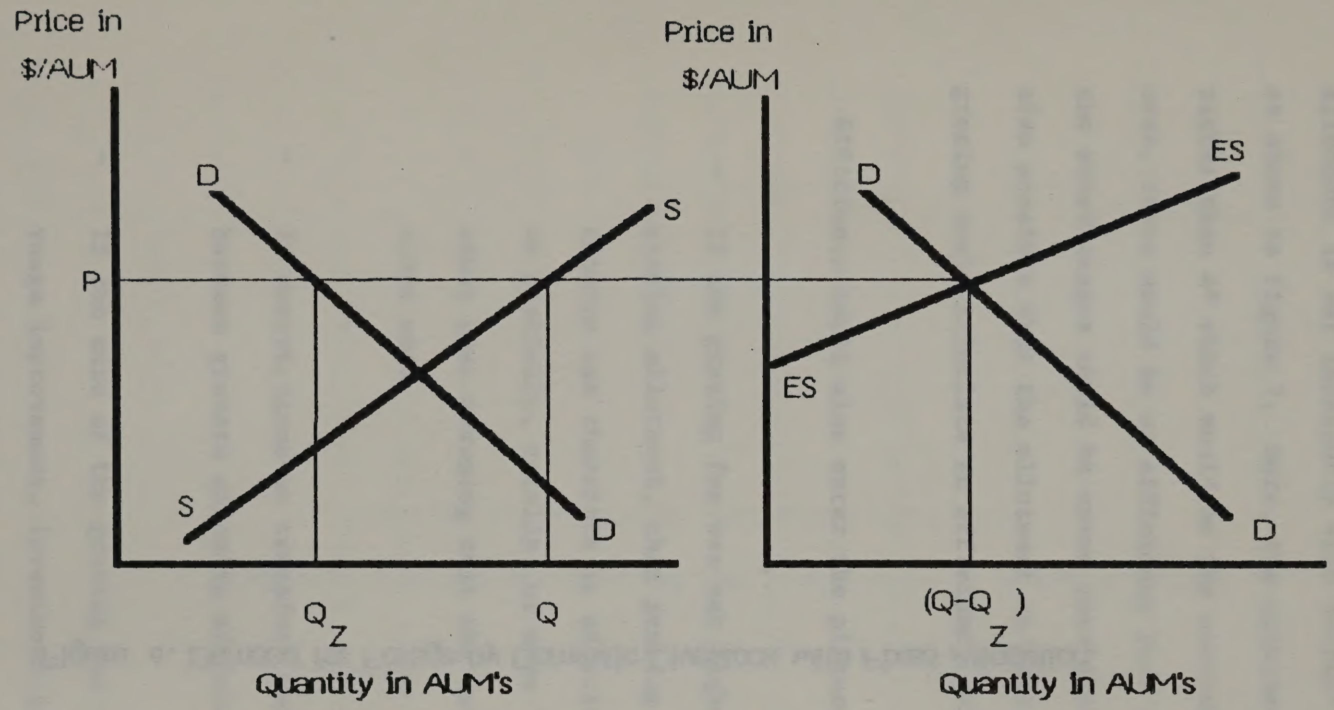


Figure 4. Supply and Demand for AUM's of Grazing.



A. Domestic Livestock

B. Other Uses

Figure 5. Division of Total Supply of Public Forage Between Domestic Livestock and All Other Uses.

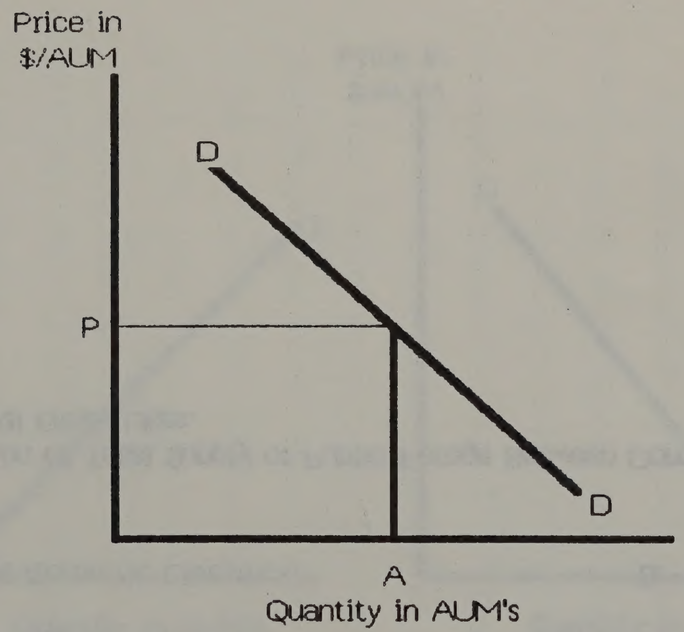


Figure 6. Demand for Forage by Domestic Livestock with Fixed Allocation.

important in that it shows that efficiency increases are generally not involved in the fee level debate as long as the allotment is binding. Equity thus becomes the principal item of concern.

However, efficiency can enter the situation as follows: suppose that the allotment is set improperly with respect to the imputed price of other usages as shown in figure 7. Here, the allotment of AUM's to grazing is set at A rather than A* which would be the economically efficient allotment. In this case, there would be an efficiency loss in that the resources A*-A allotted to the other usages could be moved into grazing with a gain in efficiency. It is also possible that the allotment to grazing is too large and a movement out of grazing could stimulate an efficiency gain.

Efficiency could also enter the picture through four other means:

- If the grazing fee was set higher than the imputed price of the grazing allotment, then grazing use would decline with a loss in net returns and therefore in efficiency to grazing. However, this could be partially, totally, or more than off-set by increased benefits from other uses assuming that the land could be efficiently employed in other uses.

- If restrictions on transfers were removed, then land could move between grazers allowing efficiency gains (see Gardner, (8)).

- If the size of the grazing fee influences the rate of investment in range improvement, investment projects with positive net present worth might go unfunded or be underfunded.

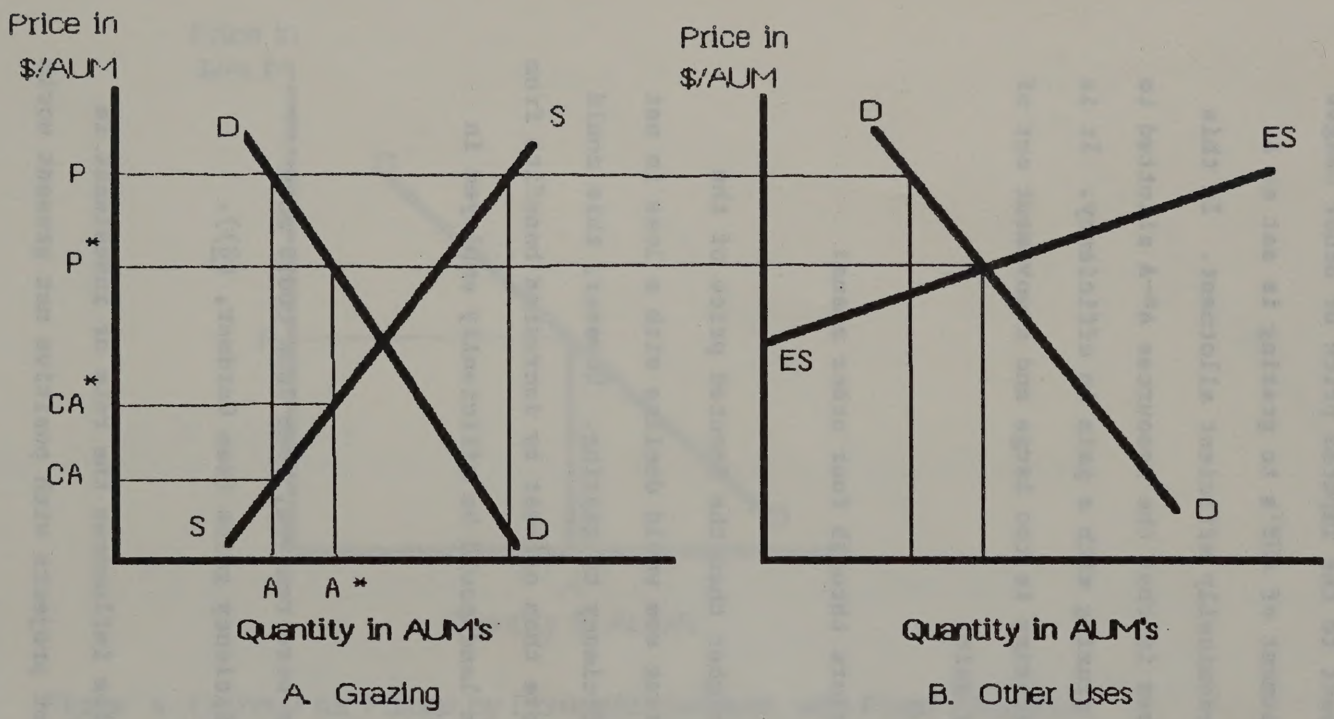


Figure 7. Example with potential gain in efficiency by change in price and allocation between grazing and other uses.

- If farmer risk attitudes cause underutilization at an "efficient" price which does not adequately consider risk, then a risk discount in the fee calculations could lead to increased efficiency.

A Welfare Analysis of Potential Changes in Fee Structure

Proposals to change fees involve altering the level of a uniform fee or making the fee variable across parcels. Both of these proposals have implications for the welfare of society and the affected parties. The purpose of this section is to analyze these accompanying welfare consequences. First, however, we need to introduce the basic tools of applied welfare analysis which are extensively treated in other places; e.g., see Just, Hueth, and Schmitz (18) and Layard and Walters (20). The two efficiency criteria most often used in applied welfare economic analysis are the Pareto Criteria and the Kaldor-Hicks Criteria defined as follows:

1. The Pareto Criterion: A social change is said to satisfy the Pareto criterion for a welfare improvement, if at least one person gains and nobody loses as a result of the change.
2. The Kaldor-Hicks Criterion: A social change is said to be a Kaldor-Hicks improvement if a change results in both gainers and losers, but the gainers can compensate the losers and still remain better off.

A Kaldor-Hicks improvement does not require that compensation actually be made; however, there is no economic basis for a welfare improvement unless compensation is made. Compensation, in fact, would need to conform to the

Pareto criterion where all losers would need to be compensated to the extent that they were not worse off while at least one gainer remained. Thus, any Kaldor-Hicks improvement becomes a Pareto improvement, if compensation is made to losers. Compensation as argued by Martin (23) also depends upon whether both gainers and losers can agree that each had a property right only to his/her original position. Resolution of disagreements over property rights is left to the courts and legislative actions in the appropriate political bodies. This has implications in the grazing fee debate in terms of permit value. The question of whether reductions in permit value should be subject to compensation depends on whether land owners have property rights to that permit value.

Finally, let us introduce the monetary measure of welfare which we will use. The measure of total welfare is consumers' plus producers' surplus. We assume it is a valid representation of welfare and that the distortion between it and the true welfare measures of equivalent and compensating variation is acceptable (see Just, Hueth, and Schmitz (18) for elaboration). Consumers' and producers' surplus graphically is the area below the demand curve but above the supply curve. This total welfare measure is distributed between producers and consumers with the portion of the area below the price line accruing to producers and that above the price line to consumers. The use of this tool to draw efficiency implications requires the assumption that decisionmakers are willing to sum the willingness-to-pay of all parties without differential weighting.

Now, let us analyze the consequences of changes in the level of grazing fees. First, we will analyze the consequences of changes in the level of the uniform fee; then, we will analyze the case of changes to a variable fee.

Uniform Fee Analysis

The welfare alteration involved with a change in fee levels depends upon whether or not the factor demand schedule for an AUM of grazing varies across parcels. The evidence above appears to show that it does, however, we will deal with both variable and constant factor demands. Other important items which need to be reflected in the welfare analysis are (a) levels of authorized grazing under each permit of lease (allotments) and (b) transfer restrictions prohibiting subleasing. Further, an important question regards the usage of idled allotments by "other" usages. We will assume that the allotments and transfer restrictions are maintained and that idled allotments either are unused or used in a less valuable manner than would occur under grazing. The converse would imply fee induced idling of the land could lead to welfare gains and would imply that a reduction in the total allotment level would be socially desirable. This is not implausible but we will assume it away for the moment.

Now, let us consider the case under which the factor demand of grazing is constant across all parcels. In this case referring to figure 8, the government allocates a given a number of grazing AUM's, which leads to a price (P). Now, suppose the government incurs a marginal cost of administration when leasing the land (C) and wishes to consider the welfare consequences of two different fee levels (F, F*). This situation is portrayed graphically in figure 8. The magnitude of the consumers' plus producers' surplus involved is equal for both alternative fees. Thus, total welfare is unchanged and a Kaldor-Hicks gain is not possible from the fee change. In this case, fee changes will lead to a total welfare change only if (a) F* becomes greater than P idling some or all of the allotment or (b) F* becomes less than C causing the administration cost not to be recovered. However, the

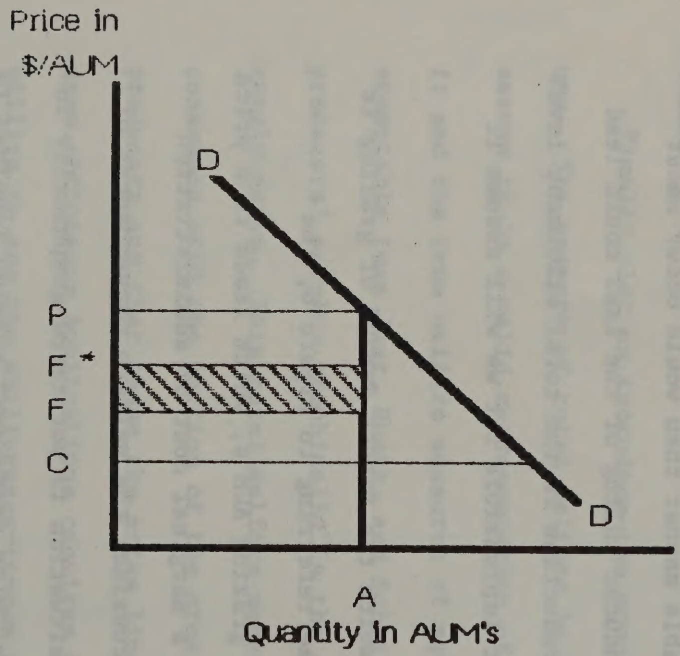
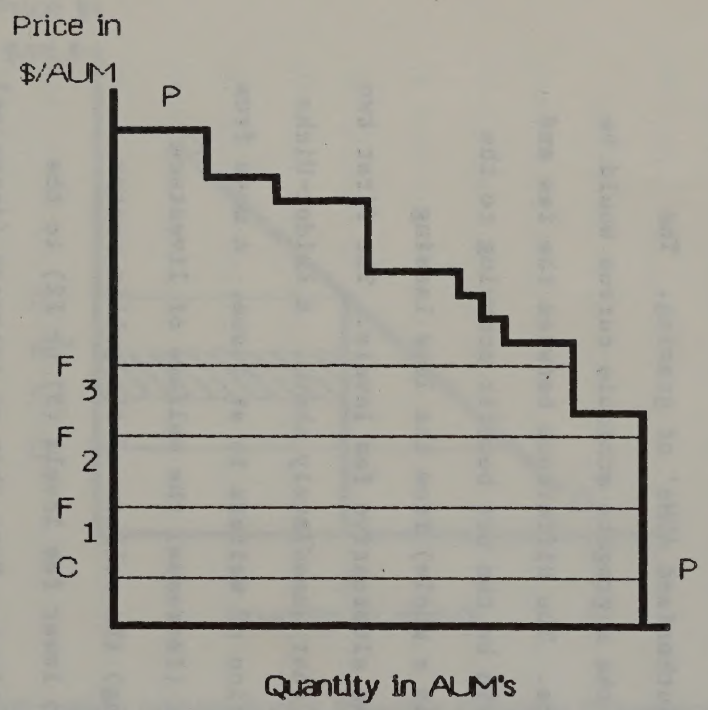


Figure 8. Aggregate Allocation of Net Social Benefits Between Government and Permittees.

distribution of welfare is at issue under the two alternative fees. The shaded area in figure 8 either (a) goes to livestock producers (who are the consumers of public land) under fee F, or (b) goes to the government in the form of additional fee collections under fee F*. Thus, equity not efficiency is the item at stake.

Now turning to the case where factor demand varies across parcels, let us utilize the empirical structure implied by the work of Gee, as shown earlier in figure 3. Suppose for simplicity that all individuals have a linear production function and therefore infinitely elastic demand for grazing up to the amount allowed on the particular parcels. Then aggregating these individual grazing schedules, we get a curve as in figure 9. The quantity (Q) on the X axis equals the government authorized AUMs' of grazing. The difference between any fee level and the aggregate schedule curves would be income accruing to livestock producers. The difference between the fee and the administration cost (C) would again be the net benefit accruing to the government (equivalently the public as a whole) from its land leasing activities. The figure contains three alternative fee levels. The first two (F1 and F2) show a case analogous to that immediately above. A Kaldor-Hicks gain cannot be attained but distribution of welfare is at issue. A move from fee F1 to F2 (F2 to F1) will decrease (increase) the welfare of livestock producers while increasing (decreasing) the welfare of the public sector. However, the move from one of the two lower fee levels (F1 or F2) to the higher fee (F3) has different implications. Note that an increase (decrease) in the fee from F1 to F3 (F3 to F1) results in a decrease (increase) in total consumers' plus producers' surplus. Thus, there is a loss (gain) of total social welfare in this case. In fact, to maximize total welfare the fee must



Figure' 9. Variable Productivity MVP Schedule and Alternative Fees.

be greater than or equal to the cost of administration but less than or equal to the imputed value of the lowest valued parcel which is above the cost of administration. Total welfare is increased only by lowering the level of the uniform fee from F3 to some lower level, from F3 to F2, not by increasing it. Total welfare can only be lost through fee increases (assuming idled parcels do not move into higher valued usages). However, the distribution of welfare is altered under either case. (Note that the sign of the change in net welfare to the government is indeterminate with fee increases depending upon the characteristics of demand)

Imposition of a Fee Which Varies Across Parcels

A potential fee system alteration involves the implementation of fees which vary across parcels depending upon their different imputed values. The analysis of the welfare effects of this system depends critically upon the administrators ability to properly set fees. For the purposes of this section, we will assume that all fees are less than or equal to the imputed value of grazing at the allowable limit (other cases are dealt with in the section on consequences of alternative fee levels and allowable limits). This case would involve the imposition of fees, such as those in figure 9 where either F1 or F2 are charged for the lowest valued parcel; F3 is charged for the next lowest valued parcel and higher fees are charged for the higher valued parcels. In this case, again total social welfare may be unchanged but the distribution of welfare is altered. The tentative "may" nature of the above statement arises due to uncertainty regarding the transactions costs involved with the implementation and collection of the variable fee. It appears unlikely that the transactions costs--the cost of administration--will

be unchanged. Under certain variable fee determination systems which require parcel-by-parcel government determination of factor demand, it appears likely that administration costs would increase more than net benefits leading to a total welfare loss. On the other hand, establishment of other variable fee systems (possibly bidding) might lead to an increase in welfare through a decrease in the cost of administration and a subsequent total welfare gain. However, no gain is possible in either case unless a variable fee will cause currently unused parcels to be utilized and/or there is a decrease in administrative costs. Efficiency is not gained on parcels currently fully utilized. The imposition of the variable fee would reduce the welfare of producers (i.e., permit value) tipping the income distribution balance toward the government. However, there might be a total welfare loss if the variable fee increase involved an increase in administration costs borne by government.

PART III. FEE SYSTEMS AND EVALUATIVE CRITERIA

Definition of Fee Systems or Fee Formulas

Eight fee systems are reviewed:

(1) The Public Rangelands Improvement Act (PRIA) formula:

$$Fee_{t+1} = Base\ [FVI_t + BCPI_t - PPI_t]/100$$

where Fee_{t+1} is the fee derived for use in year t+1 given the value of the formula component in year t. Base is the base value utilized. In the PRIA formula, a value of $1.23 is used for base value. This value was established as the average difference between the cost of grazing public and private land (including lease rate), in the 1966 survey (2, page C-29 and table 1, page C-30). This base could be maintained, changed, or varied across geographical areas (as will be done below).

FVI_t is the forage value index in year t. The index is based on a weighted average of nonirrigated private grazing land lease rates in the 11 Western states (1964-68=100), taken from an SRS survey (2, page A-19 and A-20).

$BCPI_t$ is a beef cattle price index in year t. This index is based on the weighted average selling price of beef cattle over 500 pounds in the 11 Western states from November through October, (1964-68=100).

PPI_t is a prices paid index in year t (1964-68=100), for certain items of input used in producing feeder cattle. The costs are based on a cost of production survey which is conducted jointly by ERS and SRS (2, pages C-2 to C-12). The PRIA formula is currently used to set grazing fees.

(2) Formula based on Price of Beef, BCPI.

$$Fee_{t+1} = Base * BCPI_t/100$$

where the base may be the same or different than the $1.23 used in the PRIA formula and could be varied geographically as conditions warrant. The BCPI is the same as in the PRIA formula.

(3) 1969 system, based on a forage value index, FVI.

$$Fee_{t+1} = Base * FVI_t/100$$

where the base could be the same as in the PRIA formula or varied geographically. The FVI is the same as in the PRIA formula.

(4) Formula based on an index combining the beef cattle price index and the prices paid index, CI.

$$Fee_{t+1} = Base * [BCPI_t - PPI_t + 100]/100$$

where the base could be the same as in the PRIA formula. The BCPI and PPI are the same as in the PRIA formula. This was referred to as the combined index (CI) in the 1977 report of Bergland and Andrus (2, pp.4-17, 4-18, A-13) and was prepared by the American National Cattleman's Association. This fee would be uniform across all sites.

(5) Minimum charge per AUM or agency cost per AUM, ADMIN.

$$Fee_{t+1} = \text{Cost of Administration}_t$$

This fee is based on the government encountered cost of leased land administration; i.e., the cost of establishing and collecting fees as well as the cost of management. Management includes activities directed toward monitoring range--monitoring allowable range use; and supporting and/or managing range improvement investments. Returns to the government investment in land are not considered.

(6) Forage shadow prices or residual income attributable to forage, SHADOW.

$$Fee_{t+1} = \text{Imputed Shadow Price}_t$$

This is a variable fee system which involves a site-by-site estimation of the value attributable to forage in a livestock grazing enterprise derived either by linear programming or through calculation of residual returns from enterprise cost and returns budgets.

(7) Bid System, BID.

$$Fee_{t+1} = \text{Value Set by Bidding}_t$$

This is a variable fee system. The bid system could involve fee determination through a system whereby potential land users bid on the use rights to grazing on public land. This could be accomplished through either an auction or sealed bid procedure with either procedure involving either restricted or unrestricted eligibility. A bid system would require establishment of minimum values below which permits would not be issued (see Bergland and Andrus, (2, pp.C-31 to C-58)).

(8) Fee System based on the rate of return on capitalized value of forage, CAPVAL.

$$Fee_{t+1} = (CV_t)^R$$

where CV_t is the capitalized value per AUM in year t and R is a

specified rate of return in year t. CV would need to be determined by site-by-site appraisal. A suggested rate for R is 2 percent, which Gray and Fowler (<u>14</u>) propose based on their perception of the long term rate of return on range land. No provision is made for updating these values, thus CV conceivably would need to be determined for every year or an indexing procedure developed.

Evaluative Criteria

In addition to the equity and efficiency criteria specified above, several other evaluative criteria appear relevant which have arisen within the government policy process. According to the Forest Service and BLM, any fee system should collect fair market value (FMV) for use of the forage resource. Collection of FMV is required by Congress and executive policy. The Forest Service and BLM have proposed additional criteria for evaluating fee systems. These criteria are equity, prevention of future discrepancy, use of procedures common to all government agencies, administrative feasibility, and use of data common by both government agencies (<u>2</u>, p.1-8 to 1-9). The definitions of these criteria follow.

<u>Equity</u>.

The fee system must be equitable (fair) in its treatment of interested groups and individuals both now and over time. In addition, (1) the fee should be equitable to the public returning a fair revenue to the property of value; (2) the fee should be fair to the rancher considering the value of grazing to the rancher; and (3) the fee should be fair to livestock

growers who do not have the opportunity to graze livestock on the public lands. One primary measure of equity is that fees should be similar to those charged if the resource was privately owned.

Prevent Future Discrepancy.

The fee formula should be able to reflect changes in the value of grazing rights. The fee system should include regular adjustments that would account for changes in values.

Common To All Government Agencies.

The fee system must be one that both BLM and FS can use. The law and executive policy require a uniform policy among agencies for establishing fees.

Administrative Feasibility.

The fee system must be administratively feasible. It should be readily understandable to both FS and BLM field administrators, to the ranchers, and to others having a direct interest in the public lands. It should not require extensive recurring data collection or computations that significantly increase the cost of administration. It should not require independent judgments by government personnel stationed at diverse locations. It should be compatible with the permit system and other management needs.

Use of Common Data.

The fee system must use available data series which are uniform and "historical." The data for establishment and adjustment of fees must be

common to all areas for which fees are charged. The data must cover a reasonable period of time if the effects of its use are to be correctly anticipated.

PART IV. PROPERTIES OF FORMULAS AND THEIR COMPONENTS

The economic theory discussion presented in section II allows the evaluation of the formulas relative to many of the criteria. However, the ability of the formulas to "prevent future discrepancies" and their specific make-up are unexplored issues. This section reports a theoretical and empirical investigation of the formulas and their components. The dynamic aspects will be stressed, but other comments on formula adequacy will also appear. Finally, a regression analysis is made of relationships of various indices in explaining private lease rates.

Investigations of Various Formula Components

The indices used in the PRIA formula have come under criticism, particularly the forage value index (FVI) and the prices paid index (PPI). These indices, along with the beef cattle price index (BCPI), are also used singly or in combination in other fee formulas that have been proposed. A review of these indices presented in this section.

Forage Value Index

The FVI is an index of the 11 Western state average lease rate for nonirrigated private grazing land with a base of 100 for the 1964 to 1968 average. The lease rates currently are obtained through the SRS June enumerative survey. Nelson and Garratt (27) have recently reviewed this index. The main criticisms of the FVI are as follows:

(a) The surveyed leases include a blend of long term and short term leases. The lease rate is not adjusted for differences.

(b) The respondents are asked to report their knowledge of lease rates in their area whether or not they are a leasor or leasee of private grazing land. The reason for asking those not directly involved in leasing is to increase the sample size. This method of increasing the sample size is highly questionable and could lead to biased results.

(c) Some respondents report data on an AUM basis while others utilize a head per month basis. The lease rate is not adjusted for differences.

(d) The level of landlord services connected with private lease rates varies among states as well as between private and federal leases, but the lease rate is not adjusted for these differences.

(e) The surveyed lease rate in each state is weighted by the number of operators with cattle in each state, not the number of cattle on leased land. This weighting scheme could bias the average.

All of these criticisms relate to the accuracy of the lease-rate survey results and not explicitly to the accuracy of the index derived from the survey. Nelson and Garratt (27) discuss the index at length; however, few issues are resolved.

Beef Cattle Price Index

Virtually all of the formulas utilize a cattle price index. Many indexes could be used. The one currently used--the beef cattle price index--is based on a survey of all sales of cattle and calves weighing 500 pounds and over in the 11 Western states. The relevance of this index is questionable since it includes sales of grain fed cattle, which are not a product of the range, and it excludes feeder calves under 500 pounds which are a product of the range. Since fed cattle prices exhibit the least fluctuations, and light feeder calves the greatest price fluctuations, the effect of including fed cattle in the range cattle price index is to dampen the degree to which the index fluctuates. Excluding the light feeder calves helps dampen the fluctuations even further. Thus, the BCPI will fluctuate less than the prices of those classes of cattle which are strictly a product of the range.

The classes of animals that are products of the range include slaughter cows and bulls, nonfed steers and heifers, and feeder steers and heifers. Feeder steers and heifers are further divided by weight class. The prices of these classes of animals are very highly correlated on an annual basis.

One could develop an index based on prices of the various classes of range livestock weighted by the respective proportions of total weight of each class sold. These weights could be taken from the cow/calf cost of production surveys. However, as demonstrated below, the correlations of prices among these classes of livestock are so high that an index based on the price of a single class of range livestock is virtually identical to an index based on

weighted average of all classes. Further, the correlations of annual prices among the different Western markets is so high that a reliable index can be based on a single market. In this investigation, several price series were regressed against the annual price of feeder steers, (600-700) pounds at Kansas City.

Table 3 summarizes several regressions of various beef cattle prices against the price of feeder steers (600-700) pounds at Kansas City. The price data are all annual averages. Regression 1 in table 3 shows the relationship between the beef prices used to form the beef price index and prices of feeder steers (600-700) pounds at the Kansas City Market. This regression indicates a rather high association (i.e.; 96.44 percent of the variation in the prices is explained by this equation). Regression equation 2 shows the same variables regressed as indices.

Regression 3 shows the relationship between annual average of Choice slaughter steer prices at Omaha and annual average prices of K.C. feeder steers (600-700) pounds. The amount of variance explained by this relationship is 0.9419, somewhat lower than that for regressions 1 and 2. This is to be expected since the price of feed which is not included also affects the price of feeder steers. Regression equation 5 slows the relationship between feeder heifers (300-500) pounds and feeder steers (600-700) pounds at Kansas City. The R^2 is 0.9809 which is quite high. The remaining regressions in table 1 all have R^2's greater than 0.99. Also the constant or intercept term in all remaining regressions is near zero with slope parameters near one. This means that an index of prices based on any one of these dependent variables for regressions 4 through 9 in table 1, or on a composite of them, would be essentially the same.

Table 3. Regression relationships between prices of various classes of beef cattle and price of feeder steers at Kansas City. (Numbers in parentheses are t values.)

Number	Dependent Variable	Intercept	Variable/a	R^2 /b
(1)	Average price, All beef 500 lb and over in 11 Western states	3.316 (1.921)	.788 (20.813)	.9644
			Index of K.C. Feeder Steers	
(2)	Index of Above (BCPI) 1964-8 = 100	6.9700 (1.921)	.9733 (20.813)	.9644
(3)	Choice Slaughter Steers Omaha	-3.6595 (1.705)	1.15905 (20.126)	.9419
(4)	Omaha Utility Cow	.9935 (2.162)	0.6016 (59.656	.9955
(5)	K.C. Feeder Heifers 300-500lbs	-3.9658 (-2.5000)	.9984 (28.674)	.9809
(6)	K.C. Feeder Steers 400-500lbs	-4.9577 (3.88)	1.1866 (42.199)	.9911
(7)	Colorado direct sales Feeder steers 600-700lbs	.0370 (.039)	1.0099 (47.343)	.9920
(8)	Cottonwood CA Auction Feeder Steers 600-700lbs	-.8564 (-1.976)	.9914 (97.699)	.9979
(9)	Washington-Oregon Auction Markets Feeder Steers 600-700lbs.	.6828 (.577)	9770 (51.759)	.9985
(10)	Idaho	.3718 (.190)	.9827 (31.417)	.9960

a/ Annual average price of Kansas City Feeder Steers 600-700lbs unless otherwise noted (KCFSP).

b/ R^2 can be interpreted as the amount of variance explained by the regression line. R^2 varies between zero and one.

Regressions of lighter classes of feeder steers and heifers against the annual average price of K.C. feeder steers (600-700) pounds showed an R^2 ranging from 0.9809 for 300-500 pound feeder heifers to .9911 for feeder steers 400-500 pounds. The intercepts were -3.9658 for feeder heifers and -4.9577 for feeder steers. These are quite a bit larger than intercepts for other classes of animals.

Further K.C. feeder steer (600-700 pounds) prices would be an appropriate proxy for the beef price, perhaps enabling the Statistical Reporting Service to eliminate some price series. It appears that indices of annual average prices based on a composite of the various classes of beef animals (excluding fed beef) will be very close to an index based on K.C. feeder steer prices (600-700 pounds). Conceptually, within the formulas, it appears that a composite price excluding prices of grain fed animals would be a more appropriate price than one that includes grain fed beef prices. The Kansas City feeder price series provides a more readily available set of prices than the composite used in the BCPI and conforms more clearly to the "uses common data" criteria above.

Prices Paid Index

The prices paid index (PPI) is based on a weighted average of prices paid during the 12-month period from November through October of the prices paid for certain categories of inputs. The inputs included and their respective weights are shown in table 4.

This index can be criticized regarding its relevance to Western costs. Hay and other non-range feedstuffs which make up a considerable part of

Table 4. Weights Assigned to SRS Indexes for Computing Prices Paid Index.

SRS Indexes	Weight Assigned
Fuel and Energy	14.5
Farm Motor Supplies	12.0
Autos and Trucks	4.5
Tractors and Self-Propelled Machinery	4.5
Other Machinery	12.0
Buildings and Fencing	14.5
Interest	6.0
Farm Wage Rates	14.0
Farm Services	18.0
	100.0

the expenses in many parts of the West are excluded. Gray and Fowler (14) have noted that the distribution of costs into New Mexico are quite different from those assumed in the PPI. For example, feed costs are excluded from the PPI but make up 31 percent of total costs in New Mexico. Also excluded from the PPI are seed, fertilizer, and agricultural chemicals.

In addition, physical changes in the composition of the components within the index may cause a distortion in prices over time. For example, there were dramatic changes in the capacity and reliability of self-propelled machinery items between 1964 and 1984. Failure to account for a change in the nature of the input distorts the index relative to commodities and inputs that do not change or change very little in physical composition over time.

The cost indices may also be distorted in terms of capital items because of (1) uneven purchases over time (2) the failure to adjust for after-tax prices which involves (a) a direct discount through investment credit and (b) differences between depreciation schedules allowed for income taxes and the actual physical rate of depreciation.

These considerations relative to prices paid are easily incorporated into expectations of individual firms. However, little can be done to account for them in a general analysis without incurring great expense.

Some interrelationships among indices or the variables on which the indices are based are examined next.

Interrelationships Among Indices and Formulas

Information on the interrelationships among the indices contained within the formulas is helpful toward understanding the dynamic behavior of the various proposed formulas. For a basis of comparison, we also chose the consumers price index for all items (CPI) and additional beef cattle price

indices--Kansas City feeder steers (600-700 pounds) and the 5-year moving average of Kansas City feeder steer prices. These latter two indices are substituted for the BCPI in later analyses.

The simple correlations among various indices are shown in table 5. Note that most of these indices are highly correlated with the CPI. The partial correlations of some of the same indices deflated by the CPI are shown in table 6. The undeflated indices are plotted in figures 10, 11, and 12.

The partial correlations in table 5 are more-or-less self explanatory. The two composite indices, the PRIA index and the combined index (CI) are not highly correlated with the other indices. In particular, notice that the PRIA index is not highly correlated with FVI. Consequently, the PRIA formula is a poor predictor of the FVI. The combined index is negatively correlated with all indices except the PRIA index. The negative correlation means simply that the CI generally tends to move in the opposite direction of the other indices. Correlations among the other indices are quite high, largely because of the common underlying influence of inflation which is indicated by the CPI.

The partial correlations among the indices show different patterns after each index is deflated by the CPI. A very large portion of the correlation among the undeflated indices is due to to general inflation. The correlation of deflated forage values with other deflated indices is of particular interest.

The deflated forage value index (DFVI) is negatively correlated with all other deflated indexes except the deflated PRIA index which algebraically contains the FVI. The negative correlation between the deflated indices of beef cattle prices and the deflated FVI is somewhat strange since one would expect a positive influence of prices on real forage values. When real beef prices are lowest, beef numbers have increased; therefore the demand for range

Table 5. Partial Correlations Among Specified Indexes.

	BCPI/1	PPI/2	KCFSP/3	5YAFSP/4	PRIA/5	CI/6	CPI/7
FVI /8	0.8949	0.9795	0.8418	0.9442	0.5485	-0.7007	0.9731
BCPI		0.9005	0.9830	0.9228	0.7944	-0.3680	0.9148
PPI			0.8499	0.9785	0.4793	-0.7358	0.9981
KCFS				0.8640	0.8173	-0.2864	0.8653
5YAFSP					0.5256	-0.6550	0.9861
PRIA						0.2122	0.5014
CI							-0.7094

/1 BCPI is the beef cattle index used in PRIA formula.

/2 PPI is the price paid index used in PRIA formula.

/3 KCFSP is the price of feeder steers, 600-700 pounds, Kansas City.

/4 5YAFSP is the simple 5-year moving average price of 600-700 pounds, Kansas City.

/5 PRIA is the index in the PRIA formula, FVI+BCPI-PPI.

/6 CI is a combined index which is [BCPI-PPI+100].

/7 CPI is the consumers price index, all cities, all items.

/8 FVI is the forage value index used in PRIA formula.

Table 6. Partial Correlations Among Indices Deflated by CPI.

	DBCPI	DPPI	DKCFSP	D5YAFSP	DPRIA
DFVI	-.1643	-.3132	-.2133	-.2458	.3595
DBCPI		-.2219	.9276	.3621	.7354
DPPI			-.2164	.0336	-.7639
DKCFSP				.1201	.6689
D5YAFSP					.1499

Each of the indices except the combined index of table 5 is deflated by the CPI and the partial correlations among the deflated indexes are shown. Prices used in the 5 year moving average of the deflated series was taken for D5YAFSP.

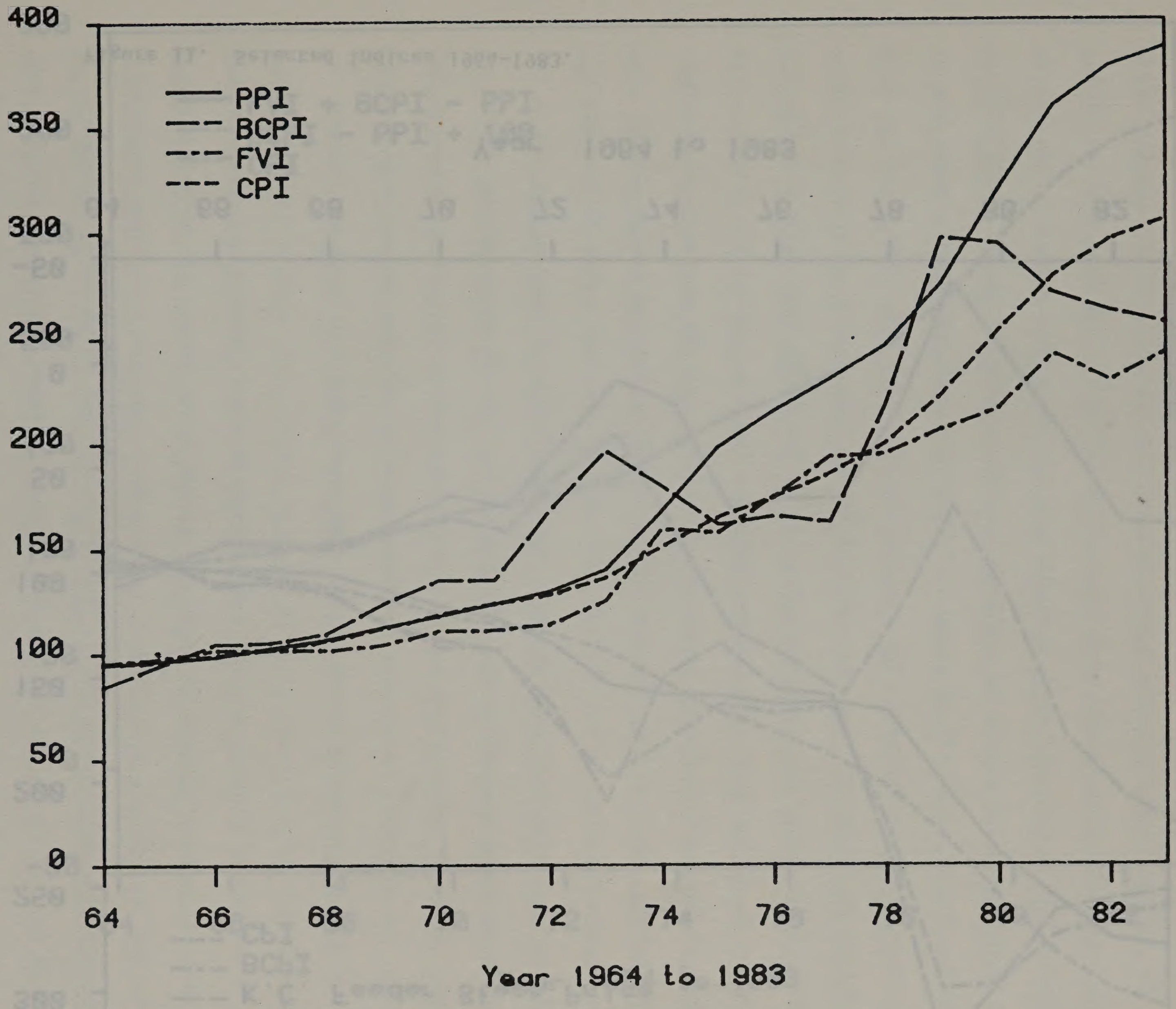


Figure 10. Selected Indices 1964-1983.

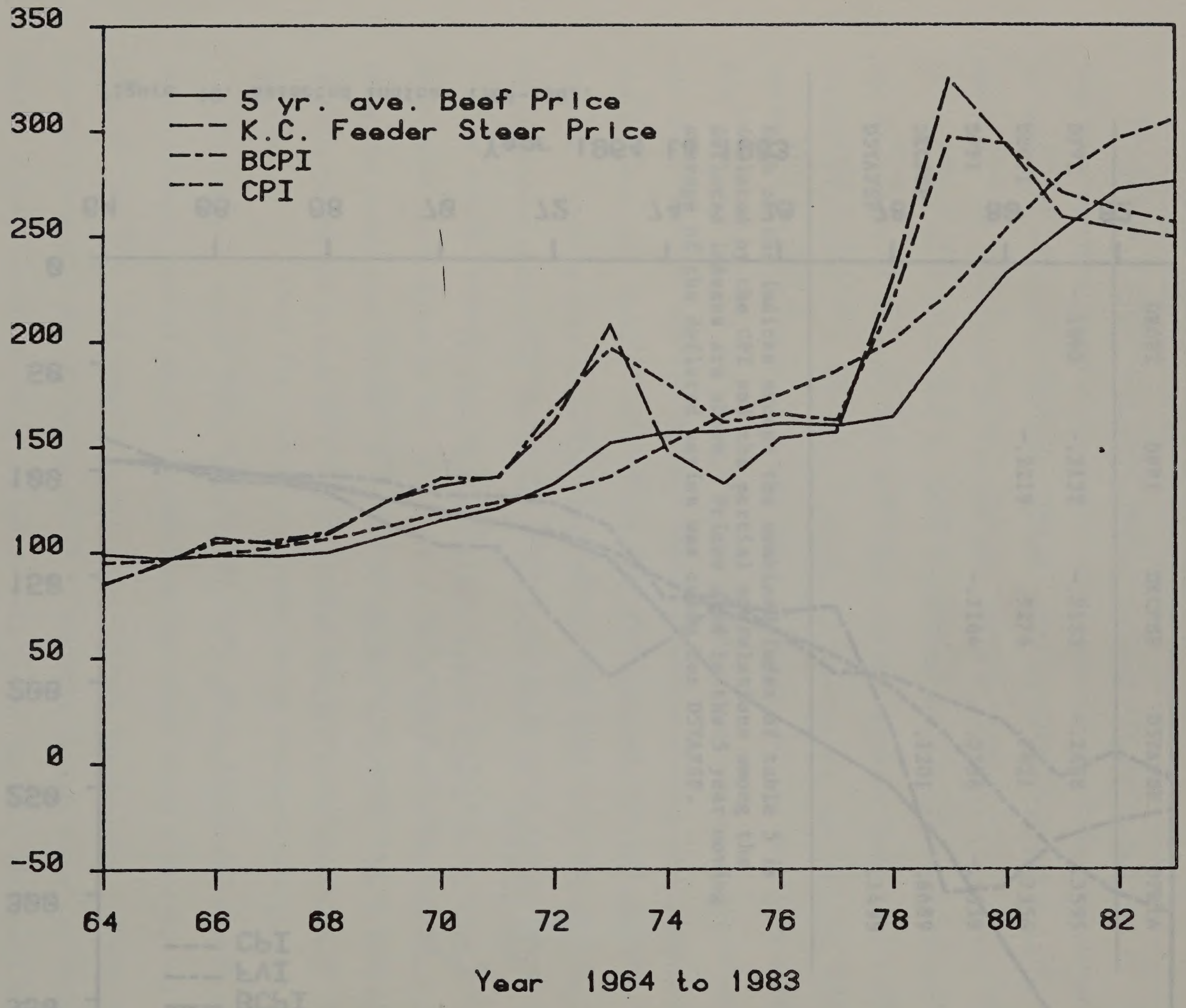


Figure 11. Selected Indices 1964-1983.

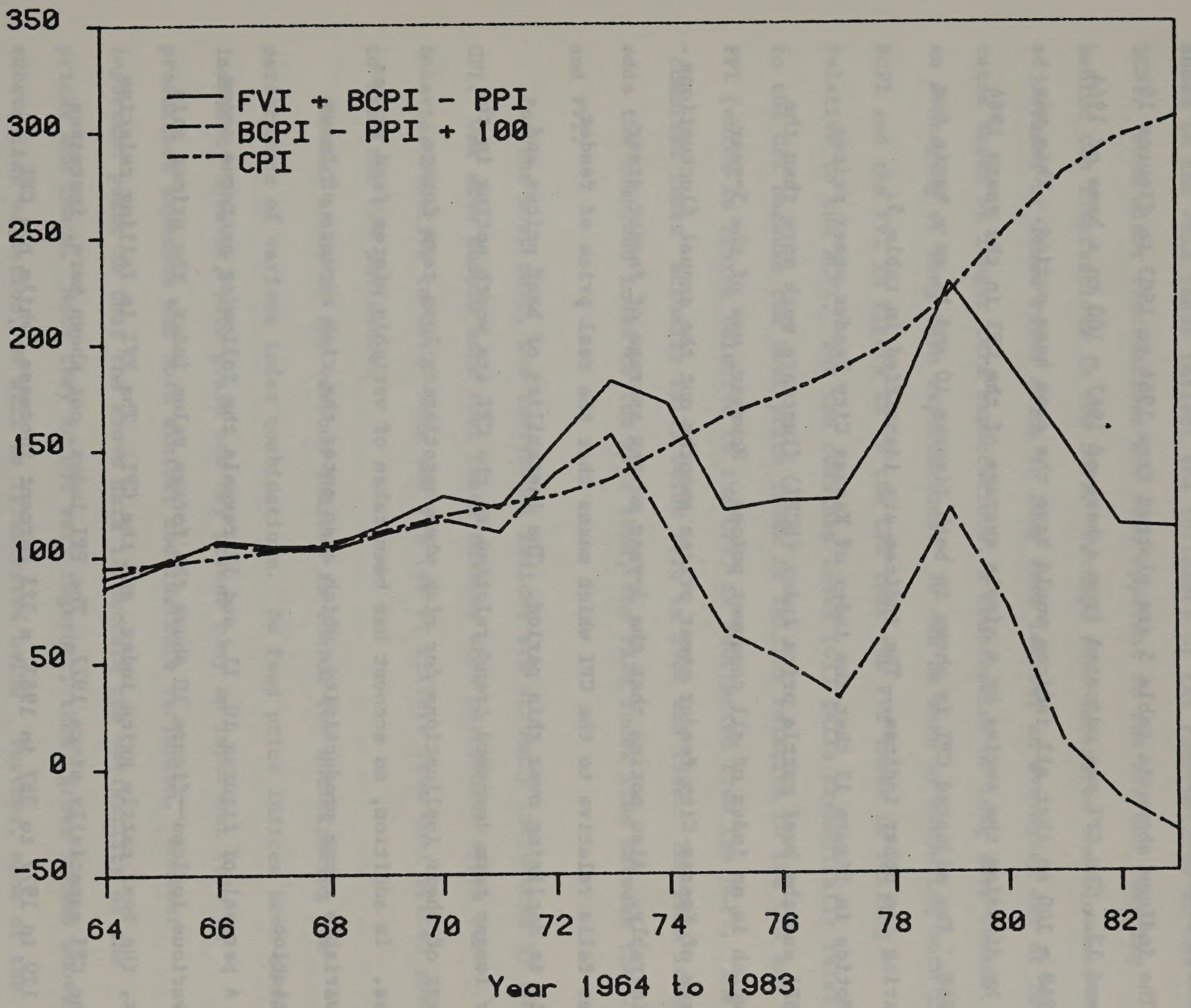


Figure 12. Selected Indices 1964-1983

may be greater relative to the supply of range during periods of low beef prices and vice versa during periods of high beef prices, while the FVI tends to remain somewhat steady.

The indices shown in table 5 are plotted from 1964 to 1983 in figures 10, 11, and 12. The CPI was adjusted from a base of 1967 = 100 to a base of 1964 to 1968 = 100 so that all indices would have the same base period. This was done by dividing the series by a simple average of the CPI in the years 1964 to 1968. The adjusted CPI is shown in both figures 10 and 11 as a basis for comparing the other indices. The indices are identified in table 5.

Notice in figure 12 that the index of Kansas City Feeder steer prices (KCFSP) and the beef cattle price index (BCPI) fluctuate much more than the CPI which is an index of all consumer prices. However, use of the 5-year average of Kansas City feeder steer prices smooths out the annual fluctuations considerably. Also notice that the 5-year moving average of feeder steer prices falls relative to the CPI which means that the real price of feeder cattle is declining over this period. The instability of beef prices and their longer term downward trend relative to the CPI are worth noting in the context of their implications for risk when negotiating long term forage leases. In addition, no account has been taken of variable winter feed prices and variable range productivity, which also enter the risk aspects of lease negotiation.

A perusal of figures 10, 11, and 12 reveals the following patterns among the various indices--figure 10 shows the forage value index, the prices paid index, the beef cattle price index, and the CPI. The FVI is falling relative to the CPI especially since 1977. The PPI index, not shown here, increases from 120 in 1977 to 387 in 1983, a 323 percent increase, while the CPI adjusted to the 1964-1968 base increase from 185.7 in 1977 to 305.24 in 1983,

a 162 percent increase. The PRIA index which contains FVI, BCPI, and PPI drops considerably relative to the CPI and FVI (figure 12). The fluctuations shown in the PRIA index reflect the influence of the fluctuations in the BCPI. Some minor fluctuations are also apparent in the FVI but they lag behind the fluctuations in the BCPI. Perhaps this indicates the slowness in adjustment of lease rates owing to long term leases, an averaging out of lease rates based on longer term expectations, a combination of long term leases, or an averaging of long term expectations. It can be seen by comparing both the BCPI and the FVI in figure 12 to the CPI that the FVI index is falling relative to the BCPI. But the combined index (CI) falls dramatically relative to the CPI because the beef price index is falling relative to the CPI and the PPI (which is rising relative to the CPI) is subtracted from the BCPI. The "combined index" actually falls below zero in 1982 and 1983. The PRIA index adds the combined index to the FVI; thus, the PRIA index lies between the CI and FVI.

For the most part, the individual indices are strongly influenced by the CPI. One also should note that these indices show particular types of behavior relative to CPI. Note the FVI (as it differs from beef price) seems to show the PPI influence.

Careful study of the various indices is useful for anticipating the performance of various index combinations. No feed price indices have been included; however, both grain and hay prices play an important role in production expenses and both exhibit considerable variation. Another important point is that the above data illustrate the variability of the prices and costs. Note they do not vary together; thus, gross income shows substantial variation, as will be illustrated below Further, none of the uncertainty in physical productivity is indicated in the indices presented above.

Ability of Formulas to Track Changing Forage Values

One of the administrative evaluative criteria involves a formula's ability to prevent future discrepancies; i.e., in tracking forage values over time. To evaluate this, we need to construct a set of forage values. This is done utilizing conceptual models which encompass factors involved in determining a parcel's forage value. Thus, conceptual models of range forage values will be developed which indicate the value in any time period and the manner by which value changes over time. Subsequently, the conceptual models will be empirically tested to discover their ability to track adjustments in private land lease rates. Before doing this, arguments on why the collected private lease rates are used to evaluate system performance are presented.

Models of Forage Value

A complete economic framework for the imputation of forage value would feature all elements of value and cost in a multiproduct, multi-input framework. This would include all alternative uses, the productivity of forage in each use, the value of all products forthcoming from each use, the requirements of other inputs associated with each use, the alternative processes by which range could be combined with other inputs in production, the prices of all outputs and inputs utilized, and all constraints on the availability of range and other inputs.

Data for such a complete framework do not exist. For example, consistent data are not available on usages of public range, other than for grazing domestic animals, along with site specific data on public land productivity. As a practical matter, the forage value for use in domestic livestock grazing

can be estimated for selected specific tracts of rangeland. However, the forage value can vary widely among tracts making it difficult and expensive to obtain precise estimates of forage value for many individual tracts. The practice has been to index a single base value year-by-year.

The question is: how adequate are the simple indexing procedures for reflecting changes over time in actual forage values? Presumably changes in forage values would arise because of marketplace changes in the value of the items produced and inputs consumed. There is also a question as to how a particular indexing procedure would affect the relative forage values on two different tracts with different annualized outputs and inputs per AUM. These questions will be addressed utilizing conceptual models.

Three models of forage value are formulated for use in analyzing the performance of the various fee formulas. Model 1 represents a construction consistent with orthodox micro economic theory. This construction is is based on a firm level production function relating physical input usage including AUM's of grazing along with other uses. Model 2 is a model for computing residual returns based on budgeting principles; i.e., the value of forage is the residual value after all other factors have been paid their value. The residual returns model is similar in construction to a linear programming shadow price. Model 3 is a model which shows the relationship between the residual returns of two different parcels. This model allows one to examine the conceptual basis for imputing the value of one parcel of land given the value of another parcel (i.e., public land given the private land grazing lease rate).

Model 1. A Production Function - Profit Maximization Model

Model 1 is based on the assumption that the firm produces according to the following production function:

$$Y = f\ (AUM, H, X..., Z)$$

where Y is output of beef and is a function of the utilization of AUM's and other inputs designated H, X, etc., up to input Z.

Assuming that the firm faces fixed exogeneous prices for all inputs and outputs, a profit maximizing firm would produce to the point where MVP equals the input price for all inputs .

$$MVP_{AUM} = P_y MPP_{AUM} = P_{AUM}$$

$$MVP_H = P_y MPP_H = P_H$$

$$\vdots \qquad \vdots$$

$$MVP_X = P_y\ MPP_X = P_X$$

where P_y is the price of the product. P_X, MPP_X and MVP_X are respectively, the input price, the marginal physical product, and the marginal value product of input X. MPP varies with the levels of all inputs.

The MVP approach to resource valuation suggests that input usage and/or input prices of all inputs, will vary as product price varies. Since firms usually do not directly control the price of inputs, a maximum profit position requires alteration of input usage. Marginal physical product will need to be adjusted to maintain equality between the marginal value product and input price. This is not always possible.

The MVP model provides a conceptual basis for using a beef price index to update forage values over time, as done in several formulas above (particularly number 2). A model for indexing MVP over time is:

$$MVP_{Xt} = P_{yo}*(BPI_t)*MPP_o*(MPPI_t)$$

where MVP_{Xt} is the marginal value product of resource X in time period t; P_{yo} is the price of product Y in the base period, t=0; BPI_t is the price index of product Y in period t; MPP_o is the marginal physical product of X in the base period; and $MPPI_t$ is an index of the marginal physical product in the period t.

The necessary condition for updating the base MVP by a beef price index (BPI) is that:

$$MVP_{Xt}=MVP_o(BPI_t)=P_{yo}(BPI_t)*MPP_o*MPPI_t=MVP_o*BPI_t*MPPI_t$$

This requires that the $MPPI_t$ equals one for all time periods, i.e., that the marginal physical product is constant over time.

A constant expected marginal physical product could occur. This would require the physical productivities of all inputs to remain constant, and also implies that the input prices vary in exact proportion both to each other and to the beef prices. Conceptually, this condition is unlikely, however, the question of how good or bad such an approximation is becomes of interest. One way to test this hypothesis is to examine how well such an index performs empirically. This is later (see the regressions on formulas 2 and 6 and the MPP regression in the section on regression results). First, two other models are developed which provide the basis for some of the other fee formulas.

Model 2 - Residual Returns Model

A residual returns model of forage valuation would develop the value of forage by attributing the residual income to grazing after paying for all other factors. This model resembles an imputation of residual returns procedures similar in form to the process underlying a linear programming shadow price. A formula depicting this process is:

(3.2) $R_{it}=P_{yt}Y_{it}-P_{ht}H_{it}-P_{Gt}G_{it}-P_{Xt}X_{it}+Z_{it}$

where R_{it} is the residual value per AUM for parcel i (i=1, 2, ..., n) in year t (t=0, 1, 2, ..., m), given that all other factors have been paid their value.

Y_{it} is the annual output of beef per AUM on parcel i in year t.

P_{yt} is the price of beef in year t.

H_{it} is the annual use of hay per AUM on parcel i in year t.

P_{ht} is the price of hay in year t.

G_{it} is the annual use of concentrate feeds per AUM on parcel i in year t.

P_{Gt} is the price of concentrate feeds in year t.

X_{it} is the annual use of all other inputs per AUM on parcel i in year t.

P_{Xt} is the price of other inputs in year t.

Z_{it} is a collection of other factors per AUM which influence forage value on parcel i in year t.

This equation calculates the forage value as the difference between enterprise revenue and enterprise cost per AUM. Physical outputs and inputs (Y, H, G, and X) are assumed to vary both over time and from parcel to parcel while the product and input prices vary over time, but not between parcels. A catchall factor (Z_{it}) is included in the cost which includes such things as risk taking, closeness to base property, and other items which may influence parcel grazing value.

Now, consider the updating characteristics of this model. Let prices in year t be the price in a base year multiplied by the index of prices in year t where

BI_t is beef price index.

PHI_t is hay price index.

PGI_t is grain price index.

PXI_t is a prices paid index.

Further, let the relevant quantity be given by its base year value miltiplied by an index of quanity use in year t where

YI_{it} is the index of production on parcel i in year t.

HI_{it} is the index of hay use on parcel i in year t.

GI_{it} is the index of grain use on parcel i in year t.

XI_{it} is the index of other input use on parcel i in year t.

ZI_{it} is the index of other factors on parcel i in year t.

Then, (3.2) becomes:

$$(3.3)\quad R_{it} = P_{yo}(BI_t)Y_{io}(YI_{it}) - P_{ho}(PHI_t)H_{io}(HI_{it}) - P_{Go}(PGI_t)G_{io}(GI_{it}) - PXo(PXIt)Xt(XIit) - Zio(ZIit)$$

Now, updating from a base period parcel value, suppose one estimates a residual return for the i th parcel in some base period, say t=0, as R_{oi}; and we wish to update this base value for time period t by an index, I_t as in formula 3:

$$R_{it} = R_{io}It$$

Strict validity of this procedure requires (a) constant physical output and inputs per AUM ($YI_{it}=HI_{it}=GI_{it}=XI_{it}=K$) with all output and input price indices varying equally to I_t ($I_t=PBI_t=PHI_t=PGI_t=PXI_t$ $=ZI_{it}$) or (b) constant prices change with all physical productivity and input use equal to I_t (the opposite of case a); or (c) the whole situation

results in a change in value which somehow equals the change in I_t. These situations seem unlikely, particularly the third one. Cases a and b also appear highly unlikely as shown by the evidence in table 5 and figures 10, 11, and 12.

Whether large discrepancies develop over time between actual returns and indexed values (when a single index is applied to a base value) depends on how disparate the price and quanity indices become. This is investigated empirically below.

Model 3. Relationship of Residual Values Between Parcels

Two of the fee formulas being evaluated use the private land lease rate index (FVI) or an adjustment of it to represent grazing land value. Thus, the "average" private land parcel's value is corrected to give the public land value. Model 3 addresses the conditions needed to adjust value between two parcels and the conditions under which discrepancies between parcels would not develop over time.

Two Model 2 equations are developed showing the residual returns for each of two parcels, i=1 and i=2. For simplicity, the time subscripts on the physical quantities are dropped requiring that they be constant over time (a condition for a proper Model 2 update). The Z factor is also omitted for simplicity.

(3.4A) $R1_t=P_{yt}Y_1-P_{ht}H_1-P_{Gt}G_1-P_{Xt}X_1$

(3.4B) $R_{2t}=P_{yt}Y_2-P_{ht}H_2-P_{Gt}G_2-P_{Xt}X_2$

where the variables are defined the same as in equation (3.3)

In addition, one may substitute $P_{yo}(BI_t)$ for P_{yt}; $P_{ho}(HI_t)$ for P_{ht}; $P_{Go}(GI_t)$ for P_{Gt} and $P_{Xo}(XI_t)$ for P_{Xt}.

Consider the formula $R_{2t}=K_tR_{1t}$. This implies the ratio R_{1t}/R_{2t} is influenced by a single time dependent updating factor, as in PRIA, BCPI, FVI, and CI formulas. What are the conditions that allow this ratio to remain constant over time so that no discrepancies emerge over time between parcels 1 and 2? Obviously, the ratio need equal K_t

$$(3.5)\quad R_{1t}/R_{2t}=P_y(BI_t)Y_1-P_h(HI_t)H_1-P_G(GI_t)-G_1-P_X(XI_t)X_1/P_yBI_tY_2-P_h(HI_t)H_2-P_G(GI_t)G_2-P_X(XI_t)X_2=K_t$$

The question is when will this occur? Several cases lead to such a situation.

a) Each parcel's value may be updated by a single index factor so that

$$R_{1t} = R_{1o}I_{1t} \text{ and } R_{2t}=R_{2o}I_{2t}$$

The consequence of this assumption is that

$$K_t= R_{1o}I_{1t}/R_{2o}I_{2t}$$

b) The empirical situation works out so that the ratio equals K_t.

c) The ratio across the parcels of the physical productivity and output equals one constant for all inputs and outputs (the same constant) as will be explained below (the discussion of equations 3.7 to 3.9 below).

Case "a" has been critiqued above (under Model 2) and does not need repeating. Case "b" is highly unlikely although it is examined empirically below.

Now, consider the formula $R_{2t}=R_{1t}+KI_t$. This would imply that the difference between R_{1t} and R_{2t} be related to a single indexing factor (I_t) multiplied by a constant over time. This is done in formulas such as PRIA or CI. Substituting indexed prices in equations 3.4A and 3.4B and subtracting equation 3.4B from 3.4A yields the following equation:

(3.6)

$$R_{1t}-R_{2t}=P_Y(BI_t)(Y_1-Y_2)-P_h(HI_t)(H_1-H_2)-P_G(GI_t)(G_1-G_2)$$
$$-P_X(XI_t)(X_1-X_2)$$

If one assumes that the difference could be indexed from the base value, then one would again have to assure (in addition to the constant input level and Z can be neglected, assumptions already made) that all price indices were identical. Thus

$$R_{1t}-R_{2t}=KI_t=(R_{1o}-R_{2o})I_{It}$$

where I_t equals all indices (BI_t, HI_t, GI_t, XI_t) and K is given by the initial difference in lease rates.

One may also obtain constancy of the difference by using second approach. Suppose that all physical qualities between the two parcels are proportional--

(3.7) $Y_2/Y_1=H_2/H_1=G_2/G_1=X_2/X_1=K$

that is output per AUM and inputs per AUM in parcel 2 are K times their respective quantities in parcel 1.

Then one may re-write equation (3.6) as

(3.8)

$R_{1t}-R_{2t}=P_Y(BI_t)Y_1(1-K)-P_h(HI_t)H_1(1-K)-P_G(GI_t)G_1(1-K)-P_X(XI_t)X_1(1-K)$

The right hand side of 3.8 can be rewritten as,

$R_{1t}-R_{2t}=R_{1t}(1-K)$

collecting terms

$R_{2t}=R_{1t}-R_{1t}(1-K)$

and simplifying,

$R_{2t}=KR_{1t}$,

one reaches the conclusion

$R_{2t}=KI_tR_{1o}$.

Hence, if the conditions where K is constant hold as in 3.7, the difference in residual returns to parcel 2 can always be written as above or as proposed in formula system FVI.

This case could easily be extended to the case where physical quantities are all different by a constant and all prices are updated by a single indexing factor. Thus, very restrictive conditions exist which are necessary to prevent growing discrepancies over time between an indexed base value and forage values under any of the formulas. First, for any individual parcel for which a base forage value is known, use of a single updating index implies (1) that price indices of all items of output and input used in production vary in precise proportion or (2) that the physical inputs and outputs indices be in precise proportion. One can also get consistent updating if the physical usages and productivities of all inputs and outputs vary according to one constant updating factor, while all prices remain constant.

These conditions are implausible. Therefore, some assessment of the magnitude of violations are useful.

One other thing should be considered while discussing these models. Models 2 and 3 is a conceptual model of the private land lease rate and the conversion to a public land lease rate. Several things can be noted from this context:

1. The PRIA formula contains the private lease rate index along with indices on beef prices and production costs. However, the private land lease rate (Model 2) does also. Thus, the PRIA formula double counts some effects.

2. One could consider the BCPI and PPI in PRIA as adjustments to the private land lease rate required in order to develop an estimate of public land lease rates. However, it is unlikely that these adjustments would work out to yield weights of plus and minus one.

3. The residual returns formula is more complex than the BCPI and PPI formulas. Following this model, an appropriate formula must either have the FVI in it or all of the terms for the input and output prices and quantities.

Investigations of Model Performance Over Time

This section presents numerical examples of the change in residual returns over time (Model 2 results) using different input and output coefficients and different sets of price indices. Then, the tracking performance of indexed base values relative to private grazing land lease rates is tested by state. Finally, regression analyses of the relationships between private grazing land lease rates and certain input and output prices are presented.

Digression -- Private Lease Rates as an Evaluative Measure

It is useful for evaluative purposes to have an empirical series against which one can measure performance of the alternative indices. Unfortunately, no such series exists for public lands. Consequently, the private land lease rate series was chosen for the evaluations. Use of this series embodies the following assumptions: the private land lease rate series responds to the same factors that the public land lease rate series does (i.e., that Model 3 exists allowing one to relate the value of one parcel to another). Thus, one assumes that the two series should vary together and that any formula which can accurately track the private lease rates would do a satisfactory job in tracking the unpriced public resource over time--given a good base value.

The analytical procedures used involve specification of the "base" in the formulas equal to the 1964-68 average of private land lease rates for the series being examined. Thus, the formula is used to update the base period lease rate. Any formula, if it works well under these tests, would satisfactorily update public land lease rates as long as the lease rates move in a parallel fashion (which is a consequence of the assumptions in the above paragraph).

Comparisons of Variation in Residual Returns

The residual returns model presented in equation (3.3) is subjected to alternate data sets to illustrate (1) the effect of changing output and input prices over time with physical productivities held constant (a) with annual prices and (b) with 5-year moving averages for prices of beef, hay and other feedstuffs, and the lagged-one-year PPI; and (2) the experiment is repeated substituting the CPI for PPI for indexing nonfeed costs.

These variations are illustrated using four data sets and the residual returns model specified in equation (3.3). All four combinations of two sets of physical data and two sets of price index data (table 7) are used. The data were selected based upon the historical situation. The physical data Y, H, and G are taken from the table on cow calf production costs, (per cow, all sizes, in the West, 1980-82; USDA (33) table 87, page 126). Y is total annual sales of all animals per cow per cwt divided by total AUM's of grazing per cow; H is total utilization of hay per cow divided by AUM's per cow; G is the combined grain and protein feed per cow divided by AUM's per cow. In set 2, the same output and feed utilization per cow is assumed but nonfeed costs are arbitrarily set at $3.65 per AUM higher in the base year (1964). The initial

Table 7. Data used in residual returns calculations 1A, 1B, 1C, 2A, 2B: $R_t = P_y Y^* BI_t - P_h H^* HI_t - P_g G^* GI_t - P_x X^* XI_t$.

Physical Data

Item [1/]	Units	Set 1	Set 2
Y	cwt beef sales/AUM	.85	.85
H	tons of hay/AUM	.243	.243
G	cwt grain & protein/AUM	.483	.483
$P_x X$	other costs,$/AUM	4.51	8.16

Initial (1964) Prices

		All sets
P_y	$/cwt beef	19.01
P_h	$/ton hay	25.88
P_g	$/cwt grain	3.53

Price Indexes

	Set A	Set B	Set C
BI_t [2/]	KCFSP (1964=100)	same	5 yr moving average
HI_t	HP (1964=100)	same	5 yr moving average
GI_t	U.S. corn price (1964=100)	same	5 yr moving average
XI_t	PPI/95	CPI/92.9	PPI/95

1/ See discussion in text on previous page.

2/ BI_t is a beef price index based on Kansas City feeder steers, 600-700 lbs.
HI_t is a hay price index based on average hay prices in 11 Western states.
GI_t is a grain price index based on Chicago corn prices.
XI_t is a prices paid index based on PPI or CPI.

1964 prices were estimated by deflating the 1982 prices back to 1964. P_y is deflated back to 1964 using the index of Kansas City feeder steer prices from the base of the 1982 weighted average price per cwt for classes of animals sold in the cow-calf cost of production budget, P_h is the 1982 weighted average hay price in the 11 Western states (1964-68=100) deflated by the hay price index. P_g is the weighted average of grain and protein cost per cwt from the cow-calf production costs table, deflated to 1964 by the corn price index.

All inputs and outputs are assumed equal in problem sets 1 and 2 except the "other" inputs item. This is used to illustrate the effect of not having proportionality of all inputs and outputs between parcels. Three sets (A, B, and C) of price indices are used. Sets A and B differ only in the index used for updating prices of other inputs (X). The PPI is used in set A, and the CPI is used in set B. The PPI probably overinflates costs of "other inputs" while the CPI under inflates these items. Set C uses 5-year moving averages for indexing beef cattle prices and feed prices. These items exhibit fluctuating prices. Some analysts have suggested using a moving average for these prices to more reasonably reflect expectations. Current prices are used for all other inputs which do not fluctuate but tend to exhibit more stablity or a stable trend in prices.

Residual returns were calculated for the five situations using the residual returns equation (3.3) by year. The first three (1A, 1B, and 1C) problems use set 1 of the physical data with sets A, B, and C, respectively, of price indices shown in table 7. Problems 4 and 5 (2A, 2B) use the physical data of set 2 and sets A and B of the price indices. Results are listed in table 8.

Table 8. Calculated residual returns by years for hypothetical problem sets 1A, 1B, 1C, 2A, and 2B compared to PGLLR. /1

	Problem set	1A	1B	1C	2A	2B	
	Production cost	Low	Low	Low	High	High	
	Other cost index	PPI	CPI	PPI	PPI	CPI	PGLLR
Year	Input Prices	Annual	Annual	5-yr ave.	Annual	Annual	
1964		3.65	3.65	3.65	0	0	3.47
1965		5.22	5.24	3.25	1.50	1.55	3.54
1966		6.66	6.64	3.06	2.85	2.80	3.61
1967		6.73	6.77	2.72	2.78	2.88	3.76
1968		7.57	7.59	2.82	3.46	3.52	3.91
1969		9.63	9.66	3.70	5.29	5.38	3.82
1970		10.32	10.28	4.48	5.79	5.66	4.05
1971		10.31	10.31	5.01	5.55	5.54	4.06
1972		13.04	13.13	5.93	8.05	8.30	4.17
1973		15.66	15.85	6.82	10.29	10.80	4.57
1974		1.29	2.10	4.15	-5.16	-2.90	5.82
1975		-2.43	-0.86	0.88	-10.04	-5.62	5.75
1976		-0.50	1.43	-1.38	-8.76	-3.34	6.37
1977		1.04	3.15	-3.55	-7.79	-1.87	7.06
1978		15.37	17.56	-3.47	5.91	12.07	7.11
1979		26.90	29.40	0.38	16.34	23.36	7.53
1980		15.64	18.80	2.19	3.38	12.27	7.88
1981		11.29	15.11	3.47	-2.51	8.22	8.83
1982		7.60	11.51	4.76	-6.92	4.06	8.36
Mean /2		8.68	9.86	2.57	1.58	4.88	5.46
S.E. /3		+6.97	+7.36	+2.86	+6.98	+6.82	+1.85

/1 Refer to text for details on the calculations under 1A, 1B, 1C, 2A and 2B. The numbers under PGLLR are the 11 state average of private grazing land lease rates.

/2 Mean value over 19 years.

/3 Standard error over 19 years.

The residual returns fluctuate widely (except for a small decrease in 1982), while the private lease rates shown in table 2 increase throughout the series. Thus, the lease rates do not follow the residual returns, except perhaps on a long term moving average. However, one still finds fluctuations in the calculated residuals, even when long term average product and input prices in a residual returns formula are used.

Problem 1c provides insight into the consequences of utilizing multiple year averages of the prices of inputs and outputs while simultaneously using current prices for the other inputs. A distortion is introduced caused by differential inflation. Basically the average prices are in a different year's money than the current prices. The longer the time periods and/or the greater the inflation rate, the greater the distortion will be. Thus, any use of multiple year price averages requires correction for inflation. Problems 1A and 2A allow one to examine the consequences of changes in individual cost items. Each problem uses exactly the same indices, but the nonfeed items of 2A are initially \$3.65 greater than in 1A. The mean residual over the 19-year period is \$7.10 greater in problem 1A than in problem 2A. The difference between 1B and 2B are the same initially as between 1A and 2A. But the difference of \$4.98 between the mean residuals of 1B and 2B is less than between 1A and 2A.

These examples show the differences in residual returns that can accrue over time when the inputs and/or outputs differ between two situations. They show the application of simple indexing procedures to be a dubious procedure. The high variability in year-to-year returns also underscores the need to consider risk aspects of fee determination. Note that only price variability is present in these examples since the assumption is made that physical productivities remained constant over the period.

The necessary conditions in a multi variable problem for the ratio of two residuals to remain constant over time is (a) that all indices are equal or (b) all inputs and outputs per unit resource are used in the same proportion between parcels. Neither (a) nor (b) exists. Rather, as noted previously (17) "...Variation among individual allotments of grazing cost per AUM was very large...within every category studied..." and "the wide variation...should be interpreted as the real situation and not as an indication of inaccurate data,...." This suggests that discrepancies among parcels will develop over time under any of the suggested indexing formulas.

Indexed Values Versus State Lease Rates

In this section, an evaluation of the tracking ability of the various fee formulas is tested against the individual state and weighted average private lease rates for the 11 Western states.

A base value for each formula is calculated as the average of lease rates over the period from 1964 to 1968 in the area to which the formula is applied. The following six indices are tested:

(1) PRIA Formula

(2) BCPI

(3) FVI

(4) Combined Index (CI) or (BCPI-PPI+100)

(5) CPI, all commodities

(6) 5YKCFPI, 5-year moving average of feeder steer prices, 600-700 pounds, Kansas City.

The first four formulas correspond to the first four formulas to be evaluated as listed above. The last two formulas are alternatives based on inflation and an alternative beef price index.

All indices were adjusted to a base of 1964 to 1968 = 100. The surveyed average of lease rates by states, and years, is shown in table 2. The 1964 lease rate is used as a base and is multiplied by various indices running from 1964 to 1981 to create an "updated" indexed series of forage values. The ratio of the indexed values to the actual lease rate is computed by year and by state. A ratio of 1 indicates the indexed value is equal to the actual surveyed lease rate. A ratio of less (more) than 1 indicates the indexed value is less (more) than the actual lease rate. These ratios are listed in tables 9 through 14.

The three bottom rows in tables 9 through 14 contain summary statistics: the average deviation is the absolute deviation from 1.0 of the ratios averaged over the 19-year period from 1964 to 1982. The mean of the ratios and the standard deviation of the ratios constitute the last two rows of each table, tables 9 through 14. The right-most column shows the mean ratio across the 11 states by year. The column labeled PGLLR refers to the 11 state average of the surveyed private land lease rates. The FVI is calculated from this 11 state average; therefore the ratio under PGLLR for the FVI is 1.0 in every year.

The key results of tables 9 through 14 are summarized in tables 15 and 16. Table 15 shows the lowest, median and highest mean absolute deviation among the 11 Western states for each of the six indices tested. The range of outcomes shown for the final year of the series are perhaps more meaningful and are presented in table 16.

Table 9. Ratios of Indexed 1964 values to actual lease rate, by state and average of eleven western states, by year. Index = FVI + BCPI - PPI.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	.88	.93	.94	.94	.94	.95	.87	.89	.84	.89	.85	.86	.90
1965	.93	1.03	1.01	1.04	1.02	1.07	.99	.92	.89	.90	.94	.87	.98
1966	.97	1.10	1.05	1.08	1.04	1.17	1.07	1.02	.94	.97	.95	.94	1.03
1967	.94	.96	.99	1.00	1.04	.82	1.02	.98	.89	.99	.87	1.06	.95
1968	.82	.93	.95	.97	1.00	1.02	1.01	.93	.89	.97	.89	1.03	.95
1969	.91	1.04	1.00	1.04	.99	1.10	1.12	1.00	.99	1.06	.97	1.00	1.02
1970	.93	1.04	1.07	1.10	1.10	1.20	1.17	1.05	1.10	1.12	1.07	1.04	1.09
1971	.88	.99	1.03	1.08	1.00	1.06	1.08	1.00	.99	1.15	1.05	1.15	1.03
1972	1.04	1.17	1.23	1.29	1.21	1.26	1.29	1.21	1.18	1.24	1.24	1.07	1.21
1973	1.13	1.31	1.29	1.41	1.30	1.16	1.39	1.28	1.23	1.41	1.34	1.22	1.29
1974	.77	1.00	.99	1.02	1.00	1.08	1.06	1.03	1.07	1.24	1.00	1.14	1.02
1975	.54	.66	.61	.71	.83	.85	.62	.68	.73	.78	.73	1.08	.70
1976	.53	.66	.54	.37	.82	.83	.69	.62	.69	.77	.75	.69	.66
1977	.53	.48	.53	.40	.70	.72	.69	.63	.71	.69	.74	.65	.62
1978	.56	.62	.67	.70	.88	1.03	.87	.72	.79	.90	.78	.65	.77
1979	.68	.76	.83	.87	1.16	1.29	1.19	.92	.96	1.06	1.02	.81	.98
1980	.56	.55	.66	.80	1.38	.71	.97	.79	.79	1.35	.78	1.05	.85
1981	.33	.43	.46	.64	.79	.60	.63	.68	.65	.70	.63	.79	.59
1982	.25	.35	.34	.45	.55	.36	.48	.46	.43	.58	.45	.67	.43
Mean Dev. 3/	.27	.23	.22	.22	.14	.19	.19	.18	.18	.18	.18	.15	.17
Mean 4/	.75	.84	.85	.89	.99	.96	.96	.88	.88	.99	.90	.93	.90
STD. 5/	.24	.27	.27	.29	.20	.24	.24	.21	.20	.23	.21	.18	.22

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 10. Ratios of Indexed 1964 values to actual lease rate, by state and average of eleven western states, by year. Index = FVI.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	.98	1.04	1.05	1.05	1.05	1.06	.97	.99	.94	.99	.94	.96	1.01
1965	.95	1.05	1.04	1.07	1.04	1.09	1.01	.94	.91	.92	.96	.98	1.00
1966	.92	1.04	1.00	1.01	.98	1.10	1.01	.97	.89	.92	.89	.96	.98
1967	.91	.93	.96	.98	1.00	.79	.99	.96	.86	.96	.85	1.00	.93
1968	.80	.91	.93	.94	.97	.99	.99	.91	.87	.95	.87	1.00	.92
1969	.82	.94	.90	.94	.90	.99	1.01	.91	.89	.96	.88	.97	.92
1970	.80	.90	.93	.96	.95	1.05	1.01	.91	.95	.98	.92	.94	.94
1971	.79	.89	.93	.98	.92	.96	.99	.91	.90	1.04	.95	1.00	.93
1972	.77	.88	.92	.96	.91	.94	.96	.90	.88	.93	.93	.97	.91
1973	.78	.91	.89	.97	.90	.79	.96	.88	.84	.97	.92	.91	.89
1974	.72	.93	.92	.96	.94	1.02	.99	.96	1.00	1.16	.93	.79	.96
1975	.71	.86	.80	.93	1.08	1.12	.81	.88	.95	1.02	.95	1.01	.92
1976	.74	.92	.74	.52	1.14	1.16	.96	.87	.96	1.08	1.04	.90	.92
1977	.80	.74	.81	.62	1.07	1.12	1.05	.96	1.09	1.06	1.14	.90	.95
1978	.65	.72	.78	.82	1.04	1.20	1.02	.84	.92	1.04	.90	.99	.90
1979	.61	.70	.76	.80	1.05	1.17	1.07	.82	.87	.96	.92	.94	.88
1980	.64	.62	.74	.90	1.56	.81	1.11	.91	.90	1.53	.88	.96	.96
1981	.52	.68	.72	1.02	1.24	.94	.99	1.07	1.02	1.10	.99	.89	.94
1982	.52	.71	.68	.92	1.09	.75	.97	.95	.87	1.17	.92	1.06	.87
Mean Dev. 3/	.24	.15	.14	.10	.10	.11	.04	.09	.09	.09	.08	.05	.07
Mean 4/	.76	.86	.87	.91	1.04	1.00	1.00	.92	.92	1.04	.94	.95	.93
STD. 5/	.13	.13	.11	.14	.15	.14	.06	.06	.06	.14	.07	.06	.04

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 11. Ratios of Indexed 1964 values to actual lease rate, by state and average of eleven western states, by year. Index = BCPI.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	.87	.92	.93	.93	.93	.94	.86	.88	.83	.88	.84	.85	.89
1965	.92	1.02	1.00	1.02	1.00	1.06	.98	.91	.88	.89	.92	.86	.96
1966	.94	1.06	1.03	1.05	1.00	1.14	1.04	.99	.92	.95	.92	.93	1.00
1967	.95	.97	1.00	1.01	1.05	.83	1.03	.99	.90	1.00	.87	1.03	.96
1968	.87	.99	1.01	1.01	1.05	1.06	1.06	.98	.94	1.02	.93	1.04	.99
1969	.98	1.12	1.07	1.11	1.06	1.18	1.20	1.07	1.06	1.14	1.04	1.05	1.09
1970	.98	1.11	1.14	1.17	1.17	1.27	1.23	1.10	1.16	1.19	1.13	1.12	1.15
1971	.97	1.09	1.13	1.19	1.11	1.17	1.21	1.10	1.10	1.27	1.16	1.21	1.14
1972	1.14	1.29	1.35	1.42	1.33	1.39	1.42	1.33	1.30	1.37	1.38	1.18	1.34
1973	1.23	1.42	1.40	1.52	1.40	1.26	1.50	1.38	1.32	1.53	1.45	1.34	1.40
1974	.81	1.05	1.03	1.08	1.06	1.14	1.12	1.08	1.12	1.30	1.05	1.23	1.08
1975	.72	.88	.82	.95	1.11	1.14	.83	.90	.97	1.04	.97	1.14	.94
1976	.70	.88	.71	.49	1.08	1.09	.91	.82	.91	1.02	.99	.92	.87
1977	.68	.62	.68	.52	.90	.93	.88	.80	.91	.89	.95	.85	.80
1978	.73	.80	.88	.92	1.16	1.34	1.15	.95	1.03	1.17	1.01	.83	1.01
1979	.89	1.00	1.08	1.14	1.51	1.68	1.55	1.18	1.25	1.38	1.34	1.06	1.27
1980	.87	.85	1.01	1.23	2.12	1.09	1.50	1.23	1.23	2.07	1.20	1.37	1.31
1981	.58	.77	.80	1.14	1.39	1.05	1.12	1.19	1.14	1.24	1.11	1.21	1.05
1982	.59	.80	.78	1.05	1.26	.85	1.11	1.08	1.00	1.33	1.05	1.18	.99
Mean Dev. 3/	.18	.14	.14	.18	.21	.18	.20	.13	.13	.24	.13	.15	.13
Mean 4/	.86	.98	.99	1.05	1.19	1.14	1.14	1.05	1.05	1.19	1.07	1.07	1.07
STD. 5/	.17	.19	.19	.24	.28	.20	.22	.16	.15	.29	.17	.17	.17

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 12. Ratios of Indexed 1964 values to actual lease rate, by state and average of eleven western states, by year. Index = CPI.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	.95	1.01	1.02	1.01	1.02	1.03	.94	.96	.91	.96	.91	.93	.97
1965	.92	1.02	1.00	1.02	1.00	1.06	.98	.90	.88	.88	.92	.95	.96
1966	.88	.99	.95	.97	.93	1.05	.96	.92	.85	.88	.86	.93	.93
1967	.90	.91	.94	.96	.98	.77	.97	.94	.85	.95	.83	.95	.91
1968	.82	.93	.95	.96	.99	1.02	1.01	.93	.89	.97	.88	.98	.94
1969	.87	.99	.95	.98	.94	1.05	1.05	.95	.94	1.01	.92	1.00	.97
1970	.84	.96	.97	1.00	1.00	1.09	1.05	.95	.99	1.02	.97	.99	.99
1971	.88	.98	1.02	1.07	.99	1.05	1.08	.99	.99	1.14	1.04	1.05	1.02
1972	.86	.97	1.01	1.06	.99	1.03	1.06	.99	.97	1.02	1.02	1.06	1.00
1973	.83	.97	.94	1.02	.95	.85	1.02	.94	.89	1.03	.98	1.00	.95
1974	.67	.87	.84	.88	.87	.94	.92	.89	.92	1.06	.87	.83	.89
1975	.72	.88	.82	.94	1.11	1.14	.83	.90	.97	1.04	.97	.94	.94
1976	.72	.90	.73	.51	1.11	1.13	.93	.84	.94	1.05	1.02	.92	.90
1977	.75	.70	.77	.58	1.00	1.04	.98	.90	1.02	.99	1.07	.88	.89
1978	.66	.72	.79	.83	1.04	1.20	1.02	.84	.92	1.05	.91	.93	.91
1979	.65	.73	.80	.84	1.10	1.23	1.14	.88	.92	1.01	.98	.95	.93
1980	.73	.72	.84	1.04	1.78	.92	1.26	1.03	1.03	1.74	1.01	1.01	1.10
1981	.59	.77	.81	1.16	1.40	1.06	1.13	1.21	1.15	1.25	1.12	1.02	1.06
1982	.65	.89	.87	1.16	1.39	.94	1.23	1.19	1.10	1.48	1.16	1.19	1.09
Mean Dev. 3/	.22	.11	.11	.11	.12	.09	.08	.09	.08	.12	.08	.06	.06
Mean 4/	.78	.89	.90	.95	1.09	1.03	1.03	.95	.95	1.08	.97	.97	.97
STD. 5/	.11	.11	.09	.17	.22	.11	.10	.10	.08	.21	.09	.08	.06

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 13. Ratios of Indexed 1964 values to actual lease rate, by state and average of eleven western states, by year. Index = 5 year moving average of feeder steer prices, 600 - 700 pounds, Kansas City, 1964 - 1968 = 100.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	1.01	1.08	1.08	1.08	1.08	1.09	1.00	1.02	.97	1.02	.97	.99	1.04
1965	.94	1.04	1.03	1.06	1.04	1.09	1.01	.93	.90	.91	.95	1.01	.99
1966	.89	1.00	.96	.98	.95	1.07	.98	.94	.86	.89	.87	.96	.94
1967	.88	.90	.93	.95	.97	.76	.95	.93	.83	.93	.82	.97	.90
1968	.79	.89	.91	.93	.96	.97	.97	.89	.85	.93	.86	.96	.90
1969	.84	.98	.93	.97	.92	1.03	1.03	.94	.92	.99	.90	.96	.95
1970	.83	.94	.96	.99	.99	1.08	1.04	.94	.98	1.01	.96	.97	.98
1971	.87	.98	1.02	1.07	.99	1.05	1.07	.99	.98	1.14	1.04	1.04	1.02
1972	.90	1.02	1.06	1.11	1.05	1.09	1.13	1.04	1.02	1.07	1.08	1.06	1.05
1973	.95	1.11	1.08	1.18	1.08	.97	1.17	1.07	1.03	1.19	1.12	1.06	1.09
1974	.71	.92	.90	.94	.93	.99	.97	.95	.98	1.14	.91	.95	.94
1975	.70	.86	.80	.92	1.08	1.12	.81	.88	.95	1.01	.95	1.00	.92
1976	.68	.85	.69	.48	1.05	1.07	.88	.79	.88	.99	.96	.90	.85
1977	.66	.61	.67	.51	.88	.92	.87	.79	.90	.88	.94	.83	.79
1978	.55	.61	.66	.69	.87	1.00	.86	.71	.77	.88	.77	.82	.76
1979	.59	.67	.73	.76	1.02	1.13	1.04	.80	.84	.93	.89	.80	.86
1980	.68	.66	.80	.97	1.67	.86	1.19	.97	.96	1.64	.95	.92	1.03
1981	.54	.72	.76	1.07	1.30	.98	1.04	1.11	1.06	1.16	1.04	.96	.98
1982	.61	.84	.81	1.09	1.30	.88	1.15	1.12	1.04	1.38	1.09	1.10	1.03
Mean Dev. 3/	.23	.15	.15	.14	.12	.08	.08	.10	.08	.13	.09	.07	.08
Mean 4/	.77	.88	.88	.93	1.06	1.01	1.01	.94	.93	1.06	.95	.96	.95
STD. 5/	.14	.16	.14	.19	.19	.10	.11	.11	.08	.19	.09	.08	.09

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 14. Ratios of Indexed 1964 values to actual lease rate by state and average of eleven western states, by year. Index = BCPI - PPI + 100.

Year	Idaho	Wyo.	Colo.	N.Mex.	Ore.	Mont.	Ariz.	Utah	Nev.	Wash.	Calif.	PGLLR 1/	Eleven State Average 2/
1964	.92	.98	.99	.98	.98	.99	.91	.93	.88	.93	.88	.90	.94
1965	.95	1.05	1.03	1.06	1.04	1.09	1.01	.93	.91	.91	.95	.91	.99
1966	.95	1.08	1.03	1.06	1.02	1.15	1.05	1.00	.93	.96	.93	.96	1.01
1967	.92	.94	.97	.99	1.02	.79	1.00	.97	.87	.97	.86	1.04	.94
1968	.81	.92	.94	.95	.98	.99	.99	.92	.88	.96	.87	1.01	.93
1969	.88	1.00	.95	.99	.95	1.06	1.07	.96	.95	1.02	.93	.98	.98
1970	.84	.96	.99	1.00	1.00	1.10	1.06	.96	1.00	1.03	.98	1.00	.99
1971	.79	.89	.93	.98	.92	.96	.99	.91	.90	1.04	.95	1.05	.93
1972	.94	1.06	1.11	1.17	1.09	1.14	1.17	1.09	1.07	1.12	1.13	.97	1.10
1973	.98	1.13	1.12	1.21	1.11	.99	1.20	1.10	1.06	1.22	1.15	1.10	1.12
1974	.51	.65	.64	.66	.66	.71	.69	.67	.70	.80	.65	.98	.67
1975	.29	.35	.33	.37	.44	.44	.32	.35	.38	.41	.38	.71	.37
1976	.21	.27	.22	.15	.33	.33	.27	.25	.27	.31	.30	.36	.27
1977	.13	.12	.13	.10	.17	.19	.17	.16	.19	.18	.19	.26	.16
1978	.24	.26	.28	.31	.38	.44	.38	.31	.34	.38	.33	.17	.33
1979	.37	.41	.45	.47	.61	.68	.63	.48	.51	.57	.55	.35	.52
1980	.22	.22	.25	.32	.54	.28	.38	.31	.31	.53	.30	.56	.33
1981	.02	.03	.03	.04	.05	.04	.05	.05	.05	.05	.05	.31	.04
1982	-.04	-.05	-.04	-.07	-.08	-.06	-.07	-.06	-.06	-.08	-.07	.05	-.06
Mean Dev. 3/	.43	.39	.38	.38	.33	.36	.36	.37	.37	.35	.38	.30	.36
Mean 4/	.57	.65	.65	.67	.70	.70	.70	.65	.64	.70	.65	.72	.66
STD. 5/	.37	.41	.41	.43	.38	.40	.42	.39	.37	.39	.38	.36	.39

1/ represents 11 state average of private grazing land lease rates.
2/ average of computed ratios of 11 western states (PGLLR excluded).
3/ mean absolute deviation from 1.00.
4/ 19 year mean of ratios.
5/ standard deviation of ratios.

Table 15. Range among 11 Western states in 19-year mean percentage absolute deviations from 100 in the ratio of indexed value to surveyed lease rates.

	Range In Mean Percent Deviation		
Index	Lowest	Median	Highest
PRIA	14	19	27
FVI	4	10	24
BCPI	13	18	24
CPI	8	11	22
5YAKCFPI	8	12	23
CI	33	37	43

Table 16. Range among 11 Western states in 1982 ratios of indexed values to surveyed lease rates.

	Range in 1982 ratio		
Index	Lowest	Median	Highest
PRIA	0.25	0.45	0.58
FVI	0.52	0.92	1.17
BCPI	0.59	1.05	1.33
CPI	0.65	1.16	1.48
KCFPI	0.61	1.09	1.38
CI	-0.08	-0.06	-0.04

The forage value index (FVI) should perform as well as or better than any other index because it is based on the data against which the comparisons are being made, although it is lagged one period. When the FVI is applied to the base value in each state, the indexed values vary widely from the actual observed state lease rates (table 10). The range in mean absolute deviations is lowest for the FVI of six indices tested (table 15). The median ratio among the 11 states for 1982 is 10 percent (table 15); however, the range varies from 0.52 to 1.53. Thus, even the FVI fails to estimate consistent forage values over the various states. Other indices perform even worse than the FVI. In this exercise, a separate base is used in each state. Had a single base been used for all states, even poorer results would have been obtained. Thus, it appears that no index can be applied to a single base without emerging discrepancies emerging between the indexed value and the actual (or true) forage value.

The performance of the PRIA index in tracking state private lease rates is shown in table 9. The range in mean absolute deviations (table 15) is from 14 to 27 percent. However, the ratios in 1982 are much smaller than 1.0. Only the combined index (CI) shown in table 14 has lower 1982 values. The CI gives negative values for 1982 (and, incidentally, even more negative values for 1983 (figure 12). The CI is clearly the poorest index but PRIA is not much better.

Results of the beef cattle price index, BCPI, are shown in table 11. The errors range from 13 to 24 percent with a median of 20 percent (table 15). The range in ratios for the year 1982 (table 16) is from .59 to 1.33 with a median of 1.05.

The CPI generates the second smallest errors (mean absolute deviations) of the six indices (table 12). Their range (table 15) is from 8 to 22 percent with a median of 11 percent. These are close to the overall results generated by the index of 5-year moving average of Kansas City feeder calves (table 13).

The most notable result of the combined index is the dramatic decline in the ratio which approaches zero in 1981 and becomes negative in 1982 and 1983.

If data for subregions within states were available, one would encounter even wider variation than is shown for the aggregations of the lease rates into statewide averages. This demonstrates the hazard of indexing a base value. If a base value representing the true value of forage to the users were available for each site for a specific production year, and each base was updated by a regionwide or nationwide index, discrepancies among sites would likely occur and become wider with time, just as in the examples shown in tables 9 through 14.

If fees were set initially at the actual forage value for each parcel and then indexed, these results would show that many parcels would become overpriced over time and their utilization discontinued while others would become underpriced. The adverse efficiency of single indexing procedures could be avoided only if the base price was low relative to forage values.

Regression Results

The empirical results of the formulas' tracking ability indicates less than ideal performance. Consequently, a regression analysis was performed to investigate the "best" (in a least squares sense) predictors of private land lease rates (PGLLR or the index of PGLLR which is FVI) since the formula weights could be varied. Functions motivated by the various fee formulas were estimated. The functions use the private land lease rate series at the individual state and 11 Western state level.

All the regressions constitute an attempt to predict the price in year t as a function of the base value multiplied an updating factor using data from year t-1. In general, the equations are

$$PGLLR_t = PGLLR_o(F(X_{t-1}))$$

The regression equation $F(X_{t-1})$ was estimated using the forage value index as the dependent variable. Thus, the equations all give results for the following equation:

$$FVI_t = PGLLR_t / PGLLR_o * 100 = F(X_{t-1})$$

where the parameters of $F(X_{t-1})$ are estimated.

The formulas are shown below. The first four formulas represent the first four fee formulas in section 3. The conditions under which the estimated function is equivalent to the corresponding formula are stated below each estimating equation. The variables are those used as in Section 3 above except as noted; a, b, c, and d are the regression parameters in each equation, and u is the error term. The subscripts denote time period with zero referring to the base year.

1. PRIA formula motivated

$$FVI_t = a + b*FVI_{t-1} + c*BCPI_{t-1} + d*PPI_{t-1} + u$$

Conditions under which formula is equivalent to specific PRIA values are

a=o, b=1, c=1, d=-1.

2. The BCPI formula motivated

$FVI_t = a + b*BCPI_{t-1} + u.$

Specific BCPI values are

a=o, b=1.

3. The FVI formula motivated

$FVI_t = a + b*FVI_{t-1} + u.$

Specific FVI values are

a=o, b=1.

4. The CI formula motivated

$FVI_t = a + b*BCPI_{t-1} + c*PPI_{t-1} + u.$

Specific CI values are

a=100, b=1, c=-1.

In addition, a number of other regressions were estimated.

5. Producer Price Index

$FVI_t = a + b*PPI_{t-1} + u$

6. 5-year moving average Kansas City feeder steer price[12/].

$FVI_t = a + b*5YAFSP_{t-1} + u$

$5YAFSP_{t-1}$ is the 5-year moving average of Kansas City feeder steer prices 600-700 pounds, lagged one period.

7. Hay price

$FVI_t = a + b*HP_{t-1} + u$

HP is the weighted average hay price, all hay, 11 Western states.

12/ A number of distributed lag and moving average models were tested to developed expected prices for range cattle and hay prices. The 5-year moving average gave the strongest correlations for both cattle and hay price variables.

8. Lagged one period 5-year moving average of hay prices ($5YAHP_{t-1}$)

$$FVI_t = a + b*5YAHP_{t-1} + c*5YAFSP_{t-1} + u$$

9. Producer price index and 5-year moving average feeder steer price.

$$FVI_t = a + b*PPI_{t-1} + c*5YAFSP_{t-1} + u$$

10. Deflated residual returns

$$FVI_t = a + b*BCPI_{t-1}/CPI_{t-1} + c*FVI_{t-1}/CPI_{t-1} + d*PPI_{t-1}/CPI_{t-1} + u$$

11. 5-year deflated moving average hay price.

$$FVI_t = a + b*d5YAHP_{t-1} + u$$

(The price series was first deflated by CIP, then a 5-year moving average calculated.)

12. Deflated hay price and producer price index

$$FVI_t = a + b*d5YAHP_{t-1} + c*PPI_{t-1}/CPI_{t-1} + u$$

The regression results are reported in table 17. The results for the first four equations (motivated by the suggested formulas) show the regression results are close to the formula system parameters only for the FVI formula. Note that a and b are close to their hypothesized values: a is not significantly different from 0 and b is approximately 1.0264. Thus, next year's lease rate has averaged about 2.64 percent higher than last years lease rate over time. This formula is subjected to further empirical scrutiny below.

The results indicate that high degrees of association (R^2) are achieved with the basic forms of the formulas and with most of the other formulas. There are, however, three items for concern: (a) coefficient stability, (b) model stability, and (c) wrong signs of the regression coefficients.

Table 17. Regressions of Formulas: National Data

(1) $$FVI_t = \underset{(.365)}{4.9682} + \underset{(.1938)}{.16489}\ BCPI_{t-1} + \underset{(2.270)}{.8254}\ FVI_{t-1} + \underset{(.018)}{.2460}PPI_{t-1} \quad R^2 = .9675$$

(2) $$FVI_t = \underset{(2.363)}{32.9026} + \underset{(9.549)}{.7223}\ BCPI_{t-1};\ R^2 = .8429$$

(3) $$FVI_t = \underset{(.460)}{3.742} + \underset{(19.876)}{1.0264}\ FVI_{t-1};\ R^2 = .9587$$

(4) $$FVI_t = \underset{(.640)}{4.7671} + \underset{(2.082)}{.16529}\ BCPI_{t-1} + \underset{(7.838)}{.8293}\ FVI_{t-1};\ R^2 = .9675$$

(5) $$FVI_t = \underset{(7.248)}{54.908} + \underset{(15.013)}{.552567}\ PPI_{t-1};\ R^2 = .9299$$

(6) $$FVI_t = \underset{(.074)}{.93699} + \underset{(12.27)}{4.0630}\ 5YAFSP_{t-1} \quad R^2 = .8985$$

(7) $$FVI_t = \underset{(5.526)}{28.1578} + \underset{(26.174)}{3.2838}\ 5YAHP_{t-1} \quad R^2 = .9772$$

(8) $$FVI_t = \underset{(3.432)}{19.41370} + \underset{(2.485)}{.92027}\ 5YAFSP_{t-1} + \underset{(8.982)}{2.61364}\ 5YAHP_{t-1};\ R^2 = .9838$$

(9) $$FVI_t = \underset{(2.470)}{41.4622} + \underset{(.536)}{.63452}\ 5YAKCFSP_{t-1} + \underset{(2.927)}{.5017233}\ PPI_{t-1};\ R^2 = .9344$$

(10) $$\frac{FVI_t}{CPI_t} = \underset{(5.265)}{.87315} + \underset{(2.442)}{1.10575}\ 5YAKCFSP_{t-1} + \underset{(7.417)}{3.39890}\ 5YADHP_{t-1} \underset{(-7.067)}{-1.04272}\ \frac{PPI_{t-1}}{CPI_{t-1}};\ R^2 = .8620$$

(11)* $$\frac{FVI_t}{CPI} = \underset{(5.120)}{.80548} + \underset{(.933)}{.50849}\ \frac{5YADHP_{t-1}}{CPI_{t-1}};\ R^2 = .0677$$

(12) $$\frac{FVI_t}{CPI_t} = \underset{(11.531)}{1.21726} + \underset{(6.081)}{3.35452}\ \frac{5YADHP_{t-1}}{CPI_{t-1}} \underset{(5.963)}{- 1.0589}\ \frac{PPI_{t-1}}{CPI_{t-1}} \quad R^2 = .7797$$

Note: t values appear in parenthesis

The models do not overwhelm one with their stability regardless of their high R^2. Model 2 is a subset of model 4 but inclusion of the variable FVI, causes a large change in the BCPI regression coefficient. Instability in the coefficients of FVI, where BCIP is excluded, is apparent, when one compares models 3 and 4. Such instability is not unexpected given the high correlation between the independent variables, as exhibited above. There are several implications of these results and their instability. First, one may be able to get "nominally" satisfactory results using adjusted formulas where multipliers other than plus or minus one are used. For example, when the 11-state average of lease rates are regressed against the variables in the PRIA formula, regression equation 1 is obtained. The resultant coefficients on the three indexes are quite different from 1.0:

$$PGLLR_t = PGLLR_o(.0498 + .00165*BCPI_{t-1} + .00825*FVI + .0024*PPI_{t-1})$$

However, the instability shows that a number of different formulas seem to yield approximately equivalent results. Second, one might be able to "improve" the formulas by trying to overcome the multicollinearity problems.

The stability of the regressions with different data was also tested. Regressions estimated for three of the formulas which showed better results at the 11-State level (BCPI, FVI, and PRIA) utilizing state data from Idaho, Montana, and New Mexico. The results are shown in table 18. These results indicate that it is indeed dubious that one would be able to use a single formula at the state level. The regression parameters for the FVI term in the FVI formula vary from .75 to 1.01 for the FVI term, whereas parameters for the PPI term in the PRIA formula varies from -.3818 to +.585 with both extremes significant.

Table 18. State Regressions for Selected Formulas,

PRIA FORMULA:

Idaho

$$FVI_{ID,t} = \underset{(.092)}{.015023} + \underset{(3.328)}{.8077}\ FVI_{ID,\ t-1} + \underset{(2.325)}{.26538}\ BCPI_{t-1} - \underset{(-.331)}{.0591}\ PPI_{t-1};\ R^2 = .9446$$

New Mexico

$$FVI_{NM,t} = \underset{(4.097)}{.8570} - \underset{(-.687)}{.18114}\ FVI_{NM,t-1} - \underset{(-1.002)}{.1597}\ BCPI_{t-1} + \underset{(3.524)}{.5850}\ PPI_{t-1};\ R^2 = .7954$$

Montana

$$FVI_{MT,t} = \underset{(.753)}{-.07606} + \underset{(6.081)}{1.080}\ FVI_{MT-t-1} + \underset{(3.938)}{.4225}\ BCPI_{t-1} - \underset{(-2.342)}{.3818}\ PPI_{t-1};\ R^2 = .9712$$

FVI FORMULA:

Idaho

$$FVI_{ID,t}\ \underset{(.417)}{.0500} + \underset{(12.877)}{1.0181}\ FVI_{ID,t-1};R^2=.9120$$

New Mexico

$$FVI_{NM,t}\ \underset{(1.614)}{.3769} + \underset{(4.410)}{.7538}\ FVI_{NM,t-1};R^2=.5486$$

Montana

$$FVI_{MT,t}\ \underset{(15.686)}{.12106} + \underset{(15.686)}{.9858}\ FVI_{MT,t-1};R^2=.9389$$

BCPI FORMULA:

Idaho

$$FVI_{ID,t} = \underset{(2.673)}{40.9372} + \underset{(7.808)}{.66886}\ BCPI_{t-1};\ R^2 = .7921$$

New Mexico

$$FVI_{NM,t} = \underset{(3.924)}{66.6577} + \underset{(4.439)}{.42179}\ BCPI_{t-1};\ R^2 = .5519$$

Montana

$$FVI_{MT,t} = \underset{(1.091)}{20.1678} + \underset{(9.018)}{9.3202}\ BCPI_{t-1};\ R^2 = .8356$$

Stability was also tested by dropping one year's data. Here, only the PPI formula was estimated, and the regression parameters varied by 10 percent and 6.9 percent respectively for the constant and coefficient on PPI.

These results raise grave doubts about the applicability of a national formula. In addition, they indicate that a regression study to "develop" good fee formulas will be complex. Finally, the instability of the FVI formula from region to region suggests that use of one national formula would yield considerable discrepancies in indexed value relative to actual lease rates among individual parcels.

The signs of the regression parameters also give one cause to question the meaning of these results. In the PRIA formulas, the estimated PPI coefficient varied from an insignificant factor to a significant negative and positive factor. Thus, these regression coefficients are not reliable for use in indicating relative weights of the different indexes.

All in all, the improved formulas may be constructed, but application at the national level appears unlikely.

Finally, a regression was estimated which is indicative of model 1 above. It tests the stability of the marginal physical product. Here, the lease rate was divided by a price expectation (the 5-year moving average). The following regression formula was estimated:

$$MPP=PGLLR_t/5YAFSP_t=.1411+.0004t;R^2=.0003$$
$$(21.566)\ (.069)$$

where t = time and numbers in parentheses are student t values.

If the lease rates represent an expectation of the marginal value of range, then division by expected price of the range product obtains the expected marginal physical product. This result suggests that, on the average in the 11 Western states, there is no change in MPP of range over time. The time variable explains virtually none of the variation in the MPP, as the R^2 is nearly zero. On the other hand, the constant term is highly significant. Its standard error is only .00654. The dimension of the constant term is one cwt of yearling equivalent beef per AUM. This can be interpreted as the marginal physical product of range on the average for the 11 Western states. In other words, this suggests that on the average, the expected marginal physical product of an AUM of privately leased range is equal to 14 pounds of yearling feeder steer. The standard error indicates two-thirds of the variation about the 14 pound average is within plus or minus 0.65 pounds.

PART V. FEE SYSTEM EVALUATION

The eight fee systems identified in Part III are reviewed in light of the economic criteria and background of Part II, the administrative criteria reviewed in Part III, and the performance tests done in Part IV. The economic criteria are economic efficiency and equity. Efficiency means obtaining the largest net social benefits from the range resource. Equity means fairness, and impartiality, in the distribution of the net social benefits among users, and the public represented by the government. Additional administrative criteria for fee systems include systems which a) prevent future discrepancies, b) can be used by all government agencies, c) are administratively feasible, and d) use common data. All eight systems are discussed under each criterion.

Economic Efficiency

There are a number of general economic efficiency issues which provide the background to the fee system evaluation. The economic efficiency issues related to allocation of public range forage among optional usages include: (1) fee levels, (2) transactions cost (cost of administration), (3) range availability for nongrazing usages, and (4) investments in range improvements.

Assuming that the allowable AUM's of grazing are set by the range manager and this limit does not result in overgrazing, all fees equal to or below the imputed price, and equal to or greater than government administrative costs per AUM, will yield the same net economic benefits from grazing. Notice that one is concerned with only the grazing issue, not other issues. Thus, economic efficiency will be unaffected by fee levels less than or equal to imputed price of grazing provided such fees cover the cost of administration.

However, efficiency can be lost by raising fees. Increases in a uniform fee level yield efficiency losses, when the fee is above any parcel's imputed price of grazing. Under this case, the grazing use of the parcel would be curtailed or discontinued, depending on whether possible adjustments in stocking rates would affect imputed price. Efficiency is also at stake when the fee is lowered below the highest imputed price of any currently unused parcels allowing them to become profitable so that they might come into production. Thus, unlike the implication of much of the previous literature, the economic efficiency of grazing will increase only if the fee levels are decreased, assuming no change in the amount of authorized grazing permitted is at issue. Any increase in fees will only decrease the total social benefits achieved from grazing, unless fees are below the cost of administration per AUM. Social gains may only be captured by lowering fees. This implies the need for a nonuniform fee, if one wishes to both increase government revenues and not decrease the economic efficiency of grazing. Conceptually, such a system could be established so that no parcel would leave production and new parcels could come in. This would be done by raising fees from the status quo for more productive parcels and lowering them for the currently unused less productive parcels. Total social benefits from grazing could thereby be increased as well as government revenue. However, such a system could involve significant transactions costs. The wide variation among parcels in forage values makes setting fees in accordance with factor demand difficult and potentially very expensive except perhaps through a bidding system. The administration cost of any new fee system would need to be exceeded by the gain in net benefits produced by grazing currently unused parcels, if any revised fee system were to increase efficiency.

A variable fee system for different geographical areas could lead to efficiency gains or at least no loss (assuming no change in allocation of

forage among usages), if the following four conditions were met. First, the fee must increase the usage of land currently not used under the uniform fee system. Second, the fee must be set high enough that it exceeds the marginal cost of administration on any new parcels. Third, the total costs of administration should not exceed those under the single fee system by more than the net benefits arising from the new parcels brought into production. Fourth, the fee system needs to maintain conditions one through three over time. Thus, to increase economic efficiency, any uniform fee can only be lowered in our variable productivity world and any variable fee may cost more than the resultant efficiency gains are worth. One may be in a no win situation.

Fee levels may also influence the efficiency of land use by influencing allocations among alternative uses. But given the current allotment system, this would occur only through changing grazing intensity, idling land, or bringing currently idle parcels into use. It is conceivable that social gains from other uses could arise by raising the uniform fee to idling parcels so the benefits from other usages would exceed the current benefits from grazing. Similarly, social gains could come from fee decreases where the benefits from grazing currently unused parcels would be greater than benefits from other uses now precluded by grazing. No evidence is available to indicate which would be the case.

Since a fixed percentage of the fees collected is designated for use in range improvement projects, fee levels may have implications for the efficiency of investments. If funds for range improvement are inadequate to fund all projects with positive present net worth and grazing fees are below the imputed value of range, then an increase in fees would increase the level of investment funds and could subsequently result in an efficiency increase, if the efficiency gain exceeded any loss due to idled parcels. However,

efficiency gains could also result from a change in the percentage of fees allocated to the investment fund without a fee increase.

Finally, in terms of general considerations, a fee system could be designed which facilitated the transfer of grazing permits from less efficient to more efficient producers. In terms of fee systems, this would only occur under a bidding system with unrestricted eligibility. Otherwise, such efficiency gains could be captured only by relaxing permit transfer restrictions which is not directly a fee issue.

The eight fee systems can now be discussed in terms of the criterion of static economic efficiency. Dynamic questions will be handled when the future discrepancy issue is examined.

First, let us characterize the system. The first four systems--the formulas (PRIA, FVI, BCPI, CI)--could be either uniform or variable fee systems. The administrative cost system (ADMIN) would be a single fee system that covers marginal costs of administration. The shadow price/residual income system, the rate of return, and competitive bid systems would be variable fee systems.

A uniform fee system based on indexing of a base value would not decrease efficiency relative to the current situation (provided current fees are above the cost of administration), unless the current fees are not held at current levels or they are lowered so that unused allotments come into production. If fees were decreased, the resultant fee would need to cover the cost of administration per AUM, but should not exceed the forage value of any parcel with value greater than the cost of administration. Any of the first four fee systems formulas could be used. There is no reason to feel that the costs of administration would vary substantially from those of the current system.

The uniform fee system implied by the marginal cost of administration would probably be the most efficient system from the grazing standpoint as it

would promote use of all parcels that had forage value equal to or greater than cost of administration and nonuse of those parcels with lower forage values.

Now, turning our attention to variable fee systems, the first four systems (e.g., PRIA, FVI, BCPI, CI) may also be used as variable fee systems by using regional or parcel specific base values. The use of such would lead to efficiency gains as long as the four criteria for variable fees mentioned in the third paragraph of this section held. The first condition (land use increase where marginal benefits exceed marginal administration cost) would most likely hold. However, the latter three (marginal and total administrative costs must be less than benefits) would be more difficult to achieve especially over time. The calculation of a proper base value could be very expensive to determine, perhaps even requiring extensive on-site visits. Dynamic maintenance could be difficult requiring large administrative costs for periodically re-establishing the base price. Tracking difficulties as discussed under the future discrepancy section below could also be a problem.

The last two formulas (SHADOW, CAPVAL) are characterized by statements just like those above regarding their performance. However, their administration costs probably would be so large that an efficiency loss would be virtually assured relative to the current PRIA or one of the other fee formula systems.

The bid system is another variable fee system. It's efficiency implications depends on:

1. The government's ability now and over time to keep the fee above administration costs (this assumes minimum fees are met).

2. If there is a change in administration costs between bidding and the current system, plus the additional net benefits of any additional parcels entering production or any additional grazing on existing parcels.
3. The extent to which bidding would ease transfer restrictions allowing potentially more efficient user access to current lands.
4. The length of lease time period and subleasing provisions, as they influence prices bid for lease (See Kelso(19) for discussion).

Potentially, a carefully designed bidding system could guarantee fees above the administration cost, encourage new parcels (with value lower than the current grazing fee) to come into production, cost less to administer than the current system (although this is far from certain), and permit more efficient users to access the public lands. Thus, potential efficiency gains exist with bidding. However, the cost of administration and the resultant fee level are large uncertain factors.

Equity

The equity issue concerns the distribution of net returns from grazing public range forage between the government and the private sector. We do not discuss equity implications on local communities (see Brokken and Radtke (4)(5)). According to the Independent Officer Appropriation Act of 1952, equity requires the government to collect full forage value. However, an issue of justice and fairness can be raised. In many cases, benefits from low fees of past policy have been capitalized into permit value and acquired by present permit holders at full capitalized value. A change in policy to collect the full forage value for each site would effect large financial

losses for those who have already paid full capitalized forage value rendering their position "inequitable," particularly with respect to private nonpermittee ranchers. On the other hand, low fees do not return "full value to the public." A change in fees requires a judgment of whose equity is more important (i.e., one must decide if increased government revenue to balance the budget is more important than the sunk costs of private ranchers). Emerging discrepancies between the value of parcels over time that might result from various indexing schemes also has equity implications from the point of view of fair and impartial fees among permittees. One can also question whether the elimination of permit value may limit the rancher's interest in maintaining the range thereby causing the government to have to increase its costs of public land management.

The investigations performed as part of this study indicate forage value per AUM varies across parcels. Our previous discussion in this paper indicate no uniform fixed fee can be equitable, if equity requires that the government receive full forage value for the leased range. Thus, uniform-national single fee applications of the PRIA, FVI, BCPI, CI or ADMIN systems would be inequitable systems.

Perhaps only the ADMIN system merits more discussion. The ADMIN by design would be a single fee system, making no attempt whatsoever toward the collection of full forage value. Thus, the equity criterion (i.e., whether the government receives full forage value) is not fully achieved by this system. Martin argued, however, that under a different definition, equity would be achieved by this system. 12/ Namely, the system is equitable to the government because their full cost of administration is recovered. It would be equitable to nonpermittees in the large majority of cases, since

12/ This comment was made by William E. Martin, Professor, University of Arizona, in a review of an earlier draft of this paper.

permittees have paid for their use of the resources through the purchase of capitalized permit value. Whether such a system would require an increase or decrease in fees from their current levels remains to be calculated and would depend on how the costs of administration were defined.

A basic theoretical conclusion is that the equity criterion (in its fair value form) mandates a variable fee system. However, the imposition of a variable fee system needs to be carefully considered since (1) a variable fee system may well increase administration cost more than the net gain in revenue which could arise, and (2) most variable fee systems tied closely to full forage value initially will develop discrepancies among parcels over time, if they are indexed.

Achieving strict equity under the variable fee implementations of PRIA, BCPI, FVI, and CI would first require a variable base almost on a parcel by parcel basis. However, even if this were done, discrepancies would emerge over time destroying the correspondence between the full forage value initially established. Thus, achieving and maintaining strict equity with an indexing approach is virtually impossible. The base capitalized value system (CAPVAL) is also subject to relative changes among parcels over time. Thus, this system also suffers from the problem of emerging discrepancies over time among parcels. Finally, one should note that the "fair market value" provisions would not be attainable if the additional government administration costs are larger than the difference in the fees collected. Under this case, the government would receive a less "fair" return than before. The same sort of considerations may be stated with respect to the shadow price-residual returns system. This system could be very expensive, difficult to update, and potentially worse than the uniform fee system.

Another variable fee option would involve a bid system with unrestricted eligibility, such a system could collect more revenue for the government than is currently being collected without decreasing the efficiency of range utilization. In fact, an increase in efficiency is possible to the extent that (1) reallocation to more efficient operators results or (2) currently unused parcels come into use. However, eligibility rules could severely restrict the bidding process to as extreme a case as one bidder per parcel. Under such restrictions, there would be bids below both full forage value and what would be offered under unrestricted eligiblity. Thus, equity would not be achieved unless the eligibility restrictions were removed.

Prevents Future Discrepancy

Under this criterion, "...the fee system should prevent future discrepancy between fees charged and fair market value (full forage value)...the formula should be able to reflect changes in the value of grazing rights over time. The fee system should include regular adjustments that would account for changes in values."(2, p.1-8)

This appears to be a large difficulty within the context of all fee systems, except possibly competitive bidding. The tracking analysis of Section IV indicates that none of the simple indices worked well in preventing emerging discrepancies in estimated forage value among parcels or regions and over time.

The results of these calculations for the following four indexes, PRIA, FVI, BCPI, and CI (and two others, the CPI and the index of 5-year moving average of feeder steer prices, Kansas City), indicate the discrepancies among individual parcels could be substantial. Apparently, any system which used base values which were a close approximation of full forage value initially

would exhibit behavior over time which could be quite inconsistent with forage values. Emerging discrepancies could cause inefficient abandonment of some leases that became overpriced through the indexing procedure and lead to lower fees and increased permit value on others. An initially efficient equitable fee system will probably not remain so for more than a few years.

Even the FVI which is based on the 11 Western state average of private grazing land lease rates does a less than perfect job of indexing base values for individual states making up the U.S. average. The range in 1982 ratios for the FVI is from .86 to 2.33; still this was the best performance of the 6 systems tested. If such tests were applied to individual leased parcels, the range in discrepancies would no doubt be even larger. We should also mention that the dynamic experiments indicate that the CI system would be totally unsatisfactory. Such emerging discrepancies would cause difficulty for any system using indexing. For example, if the base price for SHADOW were not revised every year, difficulties would arise.

The necessary conditions for updating the residual returns model without developing discrepancies over time are (1) the prices of all inputs and outputs vary together in exact proportion to each other or (2) all inputs and outputs between firms are in a fixed proportion among firms (Part III, equation 3.6). Neither condition holds. The discrepancies as shown in table 7 and 8 are examples of the variability in residual returns over time and between parcels. Thus, the residual returns/shadow price system could prevent future discrepancies only by dealing with a very large number of parcels and being frequently updated.

The two other fee systems (ADMIN and CAPVAL) would also be subject to dynamic concerns. The ADMIN system sets fees to cover the cost of administration and makes no pretense at preventing future discrepancies between the fee level and full forage values. However, government costs would

be covered. The CAPVAL system could succeed at preventing future discrepancies only by continuous re-appraisal of the relative values among parcels.

The bid system could, with unrestricted eligibility and frequent updating (perhaps every 5 years) largely prevent discrepancies among parcels and over time. However, discrepancies from fair market value could arise very prominently if competitive bidding were not obtained and maintained by loosening eligibility restrictions. Discrepancies could also arise between bidding periods whether an indexing procedure were used or not.

Administrative Feasibility

> The fee system (a) should be readily understandable to FS and BLM field administrators, to ranchers and others with direct interest in public lands, (b) should not require extensive recurring data collection or computations that significantly increase the cost of administration, (c) should not require independent judgment decisions at diverse locations, and (d) should be compatible with the permit system and other management needs.(2, p.1-9)

This criterion would seem to favor systems based on formulas--PRIA, FVI, BCPI, and CI, along with those based on administrative costs (ADMIN). Systems based on an index have apparently proven to be feasible, as supported by their past use. A administration cost-based system should be even less difficult to administer. Bidding would appear to be less favored, although it is widely used in government sales and purchase decisions. Thus, bidding should be understandable to potential users. But the bidding system may require extensive recurring data gathering. Procedural guidelines could minimize the need for independent judgments at many diverse locations but they still might be necessary. Bidding, however, could be incompatible with the permit system if the transfer restrictions are maintained restricting elibility to a single party.

The shadow price/residual returns system (SHADOW) and the rate of return system (CAPVAL) would both pose major data collection problems requiring independent judgments at diverse locations and would seem to violate the criterion.

Use of Common Data

> The fee system must use available data series which are uniform and historical. The data for establishment and adjustment of fees must be common to all areas for which fees are charged. The data must cover a reasonable period of time if the effects of its use are to be correctly anticipated.(2)

This criterion seems to indicate that a variable fee system is undesirable, given the variability of forage values. This criterion is incompatible with the criteria of under equity and preventies of future discrepancy. Such a requirement rules out the shadow price/residual returns (SHADOW) system, the rate of return system (CAPVAL) and perhaps the bid system (BID) as well. However, the PRIA, FVI, BCPI, and CI and the cost of administration system are quite compatible with this criterion.

PART VI. SUMMARY - CONCLUDING COMMENTS

The establishment of fees for private grazing on federal lands has a long history of controversy. The basic and somewhat unsolvable problem involves pricing of a nonmarketed commodity. Congress recently called for a report evaluating fee options.

This paper is presented as part of this evaluation process. First, a theoretical and technical economic framework is developed within which to review efficient allocation and pricing of federal range forage. An evaluation is then made of specific fee systems utilizing economic criteria of efficiency and equity and additional administrative criteria.

"Government" is considered in the broad sense of representing all citizens--ranging from consumers to ranchers (including those not holding grazing permits). Two government agencies, the Forest Service (FS) and Bureau of Land Management (BLM), represent the government in administering the use of public lands.

The current fee debate centers around the fee formula established in the Public Lands Improvement Act of 1978 (PRIA). The fee formula prescribed by that act is:

$$\text{Fee} = \frac{\text{Base Value}}{100}\left[\begin{array}{l} \text{Forage} \\ \text{Value} \\ \text{Index} \end{array} + \begin{array}{l} \text{Cattle Beef} \\ \text{Price Index} \\ \end{array} - \begin{array}{l} \text{Prices} \\ \text{Paid} \\ \text{Index} \end{array}\right]$$

This formula evolved through a great deal of debate and remains controversial, not only in this general conception but in the details of how the indices are derived. The Public Rangeland Improvement Act of 1978 adopted the PRIA formula as the method for setting grazing fees on a seven-year trial basis and directed the Secretaries (of Agriculture and the Interior) to report to the Congress their evaluation of the PRIA formula and other grazing fee options and their recommendation to implement a grazing fee schedule for 1986 and the subsequent years.

Several of alternative fee systems have been suggested. The eight systems evaluated are:

1. Fee based on the present formula (the PRIA) formula.
2. Fee determined by a formula based on the beef cattle price index (BCPI).
3. Fee based on a formula indexed to private grazing land lease rates (FVI).
4. Fee determined by a formula based on the beef cattle price index and index of prices paid for production inputs (combined index - CI).
5. Fee based on cost of administration (ADMIN).
6. Fee based on computed residual returns to Federal range or on linear programming shadow prices (SHADOW).
7. Fee based on competitive bidding (BID).
8. Fee based on the rate of return to capitalized forage value (CAPVAL).

The criteria for the evaluation of these fee systems arise from both economic and administrative considerations. The economic criteria involve

economic efficiency and equity. The best fee system is said to be the one which allocates the public range among competing uses--livestock grazing, wildlife habitat, recreational use and so forth--in an economically efficient manner; and is equitable among all parties in that they are treated impartially and fairly as benefits and costs are distributed.

The administrative criteria include (1) prevention of future discrepancy in values calculated from formulas based on historical relationships, (2) administrative feasibility, (3) use of the same data by all government agencies, and (4) use of procedures common to all government agencies.

Inadequately Treated Issues

A review of the grazing fee literature revealed several issues which appear to have been inadequately treated in the past. These issues include: (a) can fee increases lead to efficiency gains; (b) does forage on public lands have homogeneous value on an Animal Unit Month (AUM) basis; (c) would the fee equal the value of grazing without adjustment for uncertainty; (d) is the identification of sources of "permit value," incomplete; and (e) will simple indices adequately prevent future discrepancy between the formula value and forage value over time? Each of these are elaborated in the body of the document and are only briefly discussed here.

There appears to be a sometimes implicit, sometimes explicit, theme in the literature that increases in grazing fees will lead to increases in the economic efficiency of grazing resource usage. There can be no change in economic efficiency if there is no difference in how the resource is used and how the amount of other resources are used. Proposed fee systems changes do

not suggest also changing the allowable AUM's of grazing. As long as allowable grazing is set below the sustainable renewable limit, the only likely change in usage owing to a fee increase per se is reduced or discontinued grazing by permit holders of some of the lower valued parcels (probably a minority of cases). Given this circumstance, for efficiency to increase, decreased grazing must lead to an efficiency gain. This can only occur if: (a) there are parcels currently in use for which the marginal cost of supplying that parcel for grazing exceeds the fee; (b) the forage resources freed up by reduced grazing are used in higher valued uses; or (c) idling of parcels serves to remove transfer restrictions of permits encouraging less efficient producers to leave the market and allowing more efficient producers to acquire permits. Efficiency gains could also arise if an increase in fees leads to an increase in social efficiency through increased range investment.1/ However, the increased efficiency from such investment would have to outweigh the efficiency losses from reduced grazing. Efficiency gains could be obtained through uniform or selective fee lowering where underutilized parcels could be brought into production. The magnitude of potential efficiency gains from fee lowering depends on the extent of currently unused parcels and the prospects that the lower fees will cover the marginal cost of administration. Lowered fees may increase efficiency if (a) the fee currently exceeds the imputed value of grazing, and (b) the fee is

1/ Social efficiency means maximizing the difference between the benefits to society and the costs to society in realizing the benefits.

kept above the cost of administration provided efficient allocations to nongrazing usages are maintained. Higher fees could increase efficiency by reducing grazing in those situations where the allowable grazing exceeds the renewable limit, as the total future forage production would be increased.

Regarding homogeneity of parcel value, all the evidence indicates otherwise, that value per AUM varies across parcels (Gee (9) and Private Communication). Gee shows a wide variation in parcel values as does the 1982 SRS survey of private grazing land lease rates. This has apparently been recognized previously (Houseman (17), however, its implications have not been fully factored into the grazing fee debate. Heterogeneous value per AUM implies that any uniform fee will not collect full forage value and thereby will not satisfy the equity criterion (the consideration of an equity criteria, itself can limit efficiency). Heterogeneous value implies that any uniform fee will be less than the value of some parcels with the difference capitalized into permit values. Further, a high fee will idle some parcels. Thus, heterogeneous value will permit satisfaction of the equity criterion only through a variable fee system.

The situation is further complicated by uncertainty. Review of the data shows that the "full value" of grazing varies widely from year to year. This, coupled with a review of the basis for leasing under uncertainty, implies that grazing fees should equal the average "full value" less a risk discount.

Permit values are often mentioned as an argument for raising fees. Permit values may be created when fees are less than the value of grazing. However, there are two viewpoints which can be advanced when considering the permit value issue. These involve (a) why the permit value exists and (b) whether the existence of a permit value implies the government is receiving less than

a "fair return." Permit values arise for of several reasons. First, even under efficient pricing, there would be a return to other fixed factors within the firm providing the fee is less than the firm's maximum willingness to pay for any quantity of grazing, even if the fee equals the factor demand price (marginal value product on land) at the current quantity. This value would accrue because the permit is available. Second, disparities between the value of grazing and fees are a natural consequence of uniform pricing in a world with heterogeneous value. Third, permit value may arise because of complementary relationships between public and private resources. Thus, economic surpluses which may be capitalized into permit values will exist unless a variable fee system is adopted.

Private investment in improvements in the public range may be made as long as the fee is less than the MVP of the forage--i.e. a higher fee would capture the available economic rent and may eliminate some of the investment incentive. Also, if the possibility is strong that the permit may be withheld or transferred by the government to another rancher exists, the permit holder may be discouraged from making longer run investments even if the MVP of forage is greater than the fee.

The final issue to be discussed here involves dynamic tracking--prevention of future discrepancy. Most of the proposed fee systems contain procedures whereby base values are updated using indices. Analysis showed these procedures to embody very restrictive theoretical assumptions. Further, they perform poorly in an empirical setting. Thus, it appears highly probable that

any well designed initial base value will become inefficient and/or inequitable over time. Significant future discrepancies may then arise unless the base value is frequently revised. However, frequent revisions would imply significant government costs.

Previously Covered Issues

There are a number of other issues which merit further discussion. These involve: (a) transaction costs; (b) sources of efficiency gains other than fee changes; (c) equity; (d) lease terms; and (e) formula composition.

A major issue in the context of setting grazing fees or any other government user fees (see Gardner, (8), for elaboration) is government-borne transaction costs. In establishing any new grazing fee system, careful consideration must be given to the trade-off between the change in grazing fees revenues and the costs of obtaining them. It is possible to design a grazing fee system which nominally satisfies all the criteria but is less efficient because the gains from increased grazing and increased government fee revenue are outweighed by increased government-borne transactions costs (costs of administration).

Efficiency gains/losses may also occur via actions associated with grazing fee policy. A loosening of transfer restrictions or open bidding with unrestricted eligibility for parcel use could allow use of the grazing by more efficient producers resulting in efficiency gains. Changes in the amount of land on which grazing is permitted or in the number of head on a unit of land would change the benefits obtained through other (nongrazing) uses. This could lead to efficiency gains in some cases and losses in other cases. Similarly, alterations in range investment policies could alter the efficiency of grazing.

Equity is also an important issue. Fee increases will raise government revenues while decreasing producer income. Further, many of the producers will have paid for permit value. Total economic efficiency (change in amount of grazing) may not be substantially altered. Thus, the decision to raise (or lower) fees requires the value judgment that government revenue which could involve lower taxes, or expenditures for other government activities is more important than producer revenue. There is no economic criteria on which to base this decision. Further, even if fees were raised following the social judgment that the government should get a larger "fairer" share, one needs to be careful that transactions costs do not lower total efficiency and possible government revenues.

Lease terms are also an important issue in grazing fee policy. Various authors (for example, Kelso (16)) have argued that long term leases are the key to solving the continuous controversy over grazing fees and range use. Kelso cites the Australian example of public land leasing noting the absences of the continuous and very expensive debate that characterizes the situation in the United States.

Certainly the length of lease will affect the incentives to invest in range improvements. Adjustment for and lease provisions dealing with risk are also important issues. The absence of subleasing provisions also leads to efficiency losses.

The final issue involves formula composition. Some of the proposed formulas would require data not currently available. The criterion requiring commonly available data is reasonable. Systems such as shadow price and capitalized value violate this criteria. They require very expensive data and their use would lead to excessive government (transactions) costs. Any system considered should be carefully reviewed in terms of the potential for additional government cost. In addition, all indices used in the PRIA formula

should be improved or modified if their use in PRIA is to be continued; it might be desirable to develop a formula considering the CPI and real rather than nominal values of the other indices. It would also be desirable to examine different schemes for formula updating.

Formula Systems Evaluation

Turning to the formula system evaluation, results are summarized in the table below. Regarding future formula systems, several comments and recommendations flow from the analyses:

1. Only a variable fee system can collect full forage value on all parcels.
2. The adoption of any variable fee system other than bidding will probably lead to a greater increase in government costs than revenues, so a bidding system should be carefully considered.
3. Updating procedures for keeping items current should be reviewed carefully. It is quite difficult to develop an indexing scheme that will not lead to discrepancies in fees charged relative to forage value among parcels and over time.
4. Overall, the best systems appear to involve open-to-all bidding and maintenance of a uniform formula-based system.
5. An open-to-all-bidding system probably offers the best potential for institution of a variable fee system. It would recognize that other ranchers who do not hold permits should have an equal chance to bid for forage produced on the public range. The bids must be open to all interested parties since a bidding system with highly restrictive eligibility (as in the case under current eligibility rules) would probably not function effectively in obtaining full forage value.
6. From the point of view of efficiency, maintenance of the status quo uniform fee system without a large fee increase would avoid major

Table 19. Summary of Fee System Evaluation

Fee System	Characteristics and Criteria									
	Variable or Uniform Fee	Grazing Efficiency 1/	Government (Transactions) Cost	Equity Government Revenue	Equity Producer Revenue	Potentially Common to all Agencies	Uses Common Data	Administratively Feasible	Avoids Future Discrepancy	Comments
PRIA - Uniform Base	Uniform	a	No change	d	f	ok	ok	ok	Not very good	i
PRIA - Variable Base	Variable	b	c	e	g	ok	h	Questionable	Not very good	j
BCPI Uniform Base	Uniform	a	No change	d	f	ok	ok	ok	Not very good	i
BCPI Variable Base	Variable	b	c	e	g	ok	h	Questionable	Not very good	j
FVI Uniform Base	Uniform	a	No change	d	f	ok	ok	ok	Not very good but best of formula systems	i Best tracking of fee systems
FVI Variable Base	Variable	b	c	e	g	ok	h	Questionable	Not very good	j
CI Uniform Base	Uniform	a	No change	d	f	ok	ok	ok	Unacceptable	i Tracks very poorly
CI Variable Base	Variable	b	c	e	g	ok	h	Questionable	Unacceptable	j Tracks very poorly
Admin	Uniform	Would lead to maximum efficiency	Probably less than current cost	?	?	Costs would probably differ between agencies	ok	ok	Not relevant	k
Shadow	Variable	Could lead to maximum efficiency	Very expensive	Would probably decrease because of transactions cost	Would probably decrease	ok	no	Doubtful	Ok dependent on frequency but doesn't follow long run trends	l
CAPVAL	Variable	Could lead to maximum efficiency	Very expensive	Would probably decrease because of transactions costs	g	ok	no	Doubtful	Ok depending on frequency	l

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Characteristics and Criteria

Fee System	Variable or Uniform Fee	Grazing Efficiency 1/	Government (Transactions) Cost	Equity Government Revenue	Equity Producer Revenue	Potentially Common to all Agencies	Uses Common Data	Administratively Feasible	Avoids Future Discrepancy	Comments
Bid - By Current Permittee	Variable	Could lose efficiency with bids lower than cost of administration	?	Uncertain, could decrease due to low bids and transportations cost	Would probably increase	ok	no	?	n	Would not work well due to restrictions on bidders
Bid - Open	Variable	More efficient than closed bid	?	Probable increase depending on transactions cost	Would probably decrease	ok	no	?	n	m

a. For maximum efficiency needs to equal the MVP of the lowest valued parcel that equals or exceeds the cost per AUM of government administration .
b. Could increase efficiency if currently unused parcels were brought into use.
c. Could be costly dependent procedure for setting base fee levels and number of base levels established.
d. Fee increase would increase government revenue.
e. Would probably increase but considering government transaction costs, could decrease.
f. Fee increase would decrease producer revenue.
g. Would decrease.
h. Base prices hard to get.
i. Has major equity problems, efficiency would be decreased with fee increase, and has major tracking problem.
j. Efficiency could be increased, transactions cost could be a big factor, and has major tracking problem.
k. Has major equity problems, most efficient system, does not even try to track.
l. Transactions cost excessive, would have tracking difficulty if indexed, and data difficult to obtain.
m. probably most efficient and government equitable, would involve major policy change to open up eligibility.
n. Depends on frequency of bidding and updating procedure.

Footnote:

1/ Total social efficiency would also involve transactions cost and effects on non-grazing usages. For example a system such as SHADOW may lead to maximum grazing efficiency, but not maximum total efficiency because of large government born (transaction) costs.

policy shifts and transactions cost increases. However, the equity problem of the public not receiving its fair share would remain. The system based on the index of private lease rates or forage value index (the FVI system) appears to be the best performer if one of the uniform fee formula systems is to be used, but still exhibits problems of emerging discrepancies among parcels over time.

7. One uniform formula system that should be considered is the cost of administration system. This could lead to efficiency gains with proper and accurate estimates of the cost. Administration and determination of the cost of grazing would be difficult involving separation of grazing costs from those costs accruing to other uses.
8. The shadow price, capitalized value, and combined index systems should not be considered due to anticipated government cost in the first two cases and tracking performance in the latter.

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